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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

A SUMMARY OF EXPOSURES TO THE OFFSITE POPULATION AS A RESULT OF NUCLEAR REACTOR TESTS CONDUCTED AT THE NUCLEAR ROCKET DEVELOPMENT STATION DURING 1965

Donald T. Oakley [1]

A summary of whole-body and thyroid exposures resulting from five nuclear-reactor experiments conducted at the Nuclear Rocket Development Station during 1965 is presented. The exposures are compared with protection standards and it is shown that the exposures are small compared to the standards.

During 1965, five releases of radioactivity from the Nuclear Rocket Development Station (NRDS), were detected in the offsite area: the releases from the Kiwi Transient Nuclear Test reactor safety experiment, Experimental Plans 4, 5, and 6 of the NRX–A3, and Experimental Plan 4 of Phoebus 1–A. As a part of the Rover program, testing and disassembling of a series of reactors designated Phoebus and Nerva are being conducted at the NRDS. This work is being administered by the Space Nuclear Propulsion Office. The reactors are tested in an upright position so that the hydrogen coolant is exhausted upward along with escaping fission products. A summary of exposures from the tests is presented in the following tables; additional information may be found in the surveillance reports on each test (*1–3*). A summary of reactor test data pertinent to the surveillance is presented in table 1.

Table 1. Reactor test data

Test	Date time	Nominal operating power (megawatts)	Integral power (megawatt-seconds)
Kiwi TNT *	1/12/65 1058 PST	Transient	9.4×10^{3}
EP–4	4/23/65 1254–1258 PST	1,100	3.2×10^{5}
EP–5	5/20/65 1032–1046 PDT	1,100	1.0×10^{6}
EP–6	5/28/65 1030–1100 PDT	<500	4.3×10^{5}
Phoebus 1–A, EP–4	6/25/65 1315–1326 PDT	1,100	7.1×10^{5}

* Kiwi Transient Nuclear Test

Whole-body exposure

Monitors equipped with survey instruments recorded exposure rates due to cloud passage. From a plot of dose rate versus time, the exposure due to cloud passage has been estimated. In addition, an estimate of the infinite external exposure has been made by assuming an exposure rate decay from a residual dose rate following cloud passage. An $A_1T_1^{-1.2}=A_2T_2^{-1.2}$ decay relationship was assumed for Kiwi Transient Nuclear Test data; for the Phoebus 1–A test is a measured value of $t^{-1.15}$ was employed. The calculation does not consider the influence of an occupancy factor or of weathering, and thus will be conservative. A summary of the peak exposures at populated locations is presented in table 2. The infinite doses following EP–4 and EP–5 are given as zero; any actual deviation from this is very small.

Thyroid dose due to inhalation

Concentrations of iodine–131 and iodine–133 in air were detected following each experiment.

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Table 2. Summary of potential whole-body exposures resulting from 1965 NRDS testing

Event	Location of peak dose [a]	External whole-body gamma exposure (milliroentgens)		
		Due to cloud passage	Due to deposition (infinite external exposure)	Total exposure
Kiwi TNT [b]	Death Valley, Jct	0.23	0.44	0.67
	Hwy 95, 1.5 miles west of Lathrop Wells (unpopulated)	5.7	8.5	14.2
EP–4	Pahrump	<0.03	0	<0.03
EP–5	Goss Ranch	<0.03	0	<0.03
EP–6	No measurable dose rates off the test range complex			
Phoebus 1–A. EP–4	Diablo	0.04	1.20	1.24

[a] See figure 1
[b] Kiwi Transient Nuclear Test

A summary of the peak concentrations of radioiodine, as detected by the use of charcoal cartridges, is presented in table 3. As seen from table 3, a measured thyroid dose following Kiwi Transient Nuclear Test does not compare well with the calculated value. To a large degree, this can perhaps be accounted for by the retention of a fraction of the radioiodine that was available in particulate form, and thus collected by the prefilter.

The procedure employed to calculate the thyroid doses from inhalation is presented below. The various factors are obtained from recommendations made by the International Committee for Radiation Protection (*6*).

$$\frac{\text{Thyroid dose (D) rads}}{\frac{\text{curie-second}}{\text{meter}^3}} = f_a \cdot 3.7\times10^{10}\frac{\text{dis}}{\text{sec-curie}}$$

$$\cdot 8.64\times10^{4}\ \frac{\text{sec}}{\text{day}} \cdot E \cdot 1.6\times10^{-6}\ \frac{\text{ergs}}{\text{MeV}}$$

$$\cdot B \cdot \frac{1}{m} \cdot \frac{1}{100\ \text{ergs/gram-rad}} \cdot \int_0^{\infty} e^{-.693t/Te}\, dt$$

where

f_a = fraction of inhaled iodine that reaches thyroid = 0.23,
E = energy to thyroid/disintegration = 0.23 MeV, for ^{131}I and 0.54 MeV, for ^{133}I,
B = breathing rate = 2.32 x 10^{-4} m^3/sec,
m = mass of thyroid = 20 grams,

and Te = effective half-life
= 7.6 days for ^{131}I
= 0.87 days for ^{133}I,

yielding

$$\frac{\text{Rad}}{\frac{\text{curie-sec}}{\text{m}^3}} = 1.97 \times 10^{2} \cdot E \cdot Te,$$

$$\frac{\text{Rad}}{\frac{\text{curie-sec}}{\text{m}^3}} = 3.42 \times 10^{2}\ (^{131}I),$$

and

$$\frac{\text{Rad}}{\frac{\text{curie-sec}}{\text{m}^3}} = 9.21 \times 10^{1}\ (^{133}I).$$

Thyroid dose due to milk ingestion

Following three of the experiments conducted at the NRDS there were detectable quantities of iodine–131 in milk collected in the test site environs. As mentioned in the NRX–A3 and Phoebus 1–A reports (*2,3*), sources others than NRDS reactors could have been responsible for a portion of the activity. If one scales from data prepared by the Federal Radiation Council (*4*), it is possible to estimate the potential dose to an infant's thyroid from the milk ingestion. The FRC report assumes that a peak concentration of 8,400 pCi ^{131}I/liter will result in 1 rad to a child's thyroid due to ingestion of milk following the peak level. If one assumes that 25 percent of the dose is delivered prior to the peak being reached, then it can be calculated that 16 mrad to the thyroid result for each 100 pCi ^{131}I/liter at the time of peak concentration. However, scaling by this method assumes that the contamination was a result of a single event, and it is necessary to consider this possible source of error in judging the dose estimate.

A summary of the milk-sampling results is presented in table 4. Analyses of samples collected in Nevada and southern California following Kiwi Transient Nuclear Test did not indicate the presence of iodine–131. This probably reflects the fact that at the time of the test most of the animals were on stored feed. In addition, samples collected following NRX–A3, EP–4, did not contain radioiodine.

Table 3. Summary of estimated potential adult thyroid doses through inhalation as a result of 1965 NRDS experiments [a]

Event	Location of peak concentration [a]	Iodine-131		Iodine-133		Total thyroid dose (mrad)
		pCi-sec/m³	Millirad [b] to thyroid	pCi-sec/m³	Millirad [b] to thyroid	
Kiwi TNT [c]	Death Valley Jct.	ND	0	2.4×10^{5}	<0.1	<0.1
	Hwy 95, 1.5 miles west of Lathrop Wells (unpopulated)	8.6×10^{3}	0.29	1.7×10^{6}	0.16	[d] 3.3
EP-4	Pahrump	1.1×10^{5}	<0.1	3.4×10^{5}	<0.1	<0.1
EP-5	Hiko	3.0×10^{4}	<0.1	5.4×10^{4}	<0.1	<0.1
	Coyote Summit (unpopulated)	4.0×10^{5}	0.14	6.0×10^{5}	<0.1	<0.2
EP-6	Lathrop Wells	3.6×10^{4}	<0.1	4.2×10^{4}	<0.1	<0.1
Phoebus 1-A, EP4	Diablo	6.0×10^{4}	<0.1	2.0×10^{5}	<0.1	<0.1
	Queen City Summit (unpopulated)	5.5×10^{5}	0.19	1.6×10^{6}	0.15	0.34

[a] See figure 1.

[b] The thyroid dose conversion factors for iodine-131 and iodine-133 are $3.42\times10^{-7}\ \frac{\text{mrad}}{\text{pCi-sec/m}^3}$ and $9.21\times10^{-8}\ \frac{\text{mrad}}{\text{pCi-sec/m}^3}$, respectively.

[c] Kiwi Transient Nuclear Test.

[d] Dose determined by *in vivo* counting, monitored at this station. If substantial amounts of radioiodine in the prefilter were assumed to be biologically available, the potential dose based on air concentration would be even higher.

ND, not detectable.

Table 4. Summary of potential thyroid exposures from milk ingestion resulting from 1965 NRDS experiments

Event	Locations where iodine-131 was detected in milk [a]	Milk radioassay data peak iodine-131 (pCi/liter)	Calculated thyroid exposure (mrad) [b]
EP-5	Hiko	90	15
EP-6	Springdale	70	11
Phoebus 1-A, EP-4	Alamo	50	8
	Hiko	60	9
	Blue Eagle	180	29
	Currant	20	3

[a] See figure 1.

[b] 16 mrad/100 pCi ^{131}I/liter, at peak.

Table 5. Comparison of AEC protection standards with 1965 NRDS effluent effects

Type of exposure	AEC Radiation Protection Standards for suitable samples of the general population		Maximum potential exposure encountered in the offsite area (millirem)
	Based on exposure to individual (millirem/yr)	Based on average exposure to a suitable population sample (millirem/yr)	
Whole-body	500	170	14.2 (Lathrop Wells unpopulated) 1.2 (Diablo)
Thyroid	1,500	500	29 (Blue Eagle Ranch) 24 (Hiko) [a]

[a] Sum of exposures from EP-5 (5/20/65) and Phoebus 1-A, EP-4 (6/25/65).

Conclusions

The levels of radioactivity encountered off the test-range complex as a result of 1965 NRDS tests were small fractions of the AEC Radiation Protection Guides (*5*). The dose at any one location was limited by the infrequency of testing and the varied directions of the five experiment "hot lines" (figure 1).

By assuming that 1-milliroentgen exposure produces 1 millirad or 1 millirem absorbed dose, a comparison of the 1965 results with the AEC protection standards has been made in table 5.

A comparison of tables 3 and 4 indicates that the contribution to the thyroid exposure from inhalation was negligible. Table 4 shows the potential exposure due to milk ingestion from Schofield Dairy at Hiko and from the Blue Eagle Ranch. The milk from Hiko, representing 150 cows, is potentially capable of delivering a larger integrated dose to a population, although

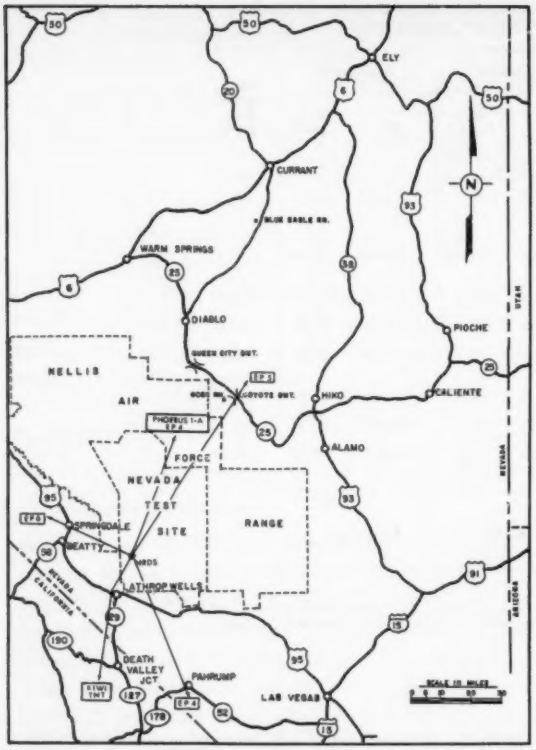

Figure 1. Sampling locations and "hot lines" of 1965 NRDS experiments

the milk from one cow at Blue Eagle Ranch had the higher concentrations of iodine–131.

A summary of whole-body and thyroid exposures resulting from five nuclear reactor experiments conducted at NRDS during 1965 has been presented. The exposures have been compared with protection standards, and it has been shown that the exposures are small compared to the standards. The potential exposure of radionuclides to the individual as a result of these reactor experiments is based on data obtained at unpopulated locations.

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Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; however, they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1965	June 1966

1. Pasteurized Milk Network September 1966

National Center for Radiological Health and National Center for Urban and Industrial Health, PHS

The Public Health Service's Pasteurized Milk Network (PMN), was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports (1)*.

The results for the third quarter of 1966

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of radionuclides in pasteurized milk for the third quarter 1966 and September 1966

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)		Barium-140 (pCi/liter)	
		Third quarter 1966	Sept * 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966	Third quarter 1966	Sept 1966
Ala:	Montgomery	<5		12	12	0	0	20	15	0	0
Alaska:	Palmer	<5	<5	11	10	0	0	30	25	0	0
Ariz:	Phoenix	<5	<5	3	4	0	0	10	5	0	0
Ark:	Little Rock	5		24	24	0	0	25	20	0	0
Calif:	Sacramento	<5	<5	4	4	10	0	10	10	0	0
	San Francisco	<5	<5	4	4	0	0	15	15	0	0
C. Z:	Cristobal	<5		4	4	0	0	15	15	0	0
Colo:	Denver	<5	<5	8	7	0	0	15	10	0	0
Conn:	Hartford	<5	<5	11	10	0	0	30	25	0	0
Del:	Wilmington	<5	<5	12	12	0	0	25	20	0	0
D.C:	Washington	<5		11	10	0	0	15	10	0	0
Fla:	Tampa	<5		10	10	0	0	130	125	0	0
Ga:	Atlanta	5		19	19	0	0	35	30	0	0
Hawaii:	Honolulu	<5	<5	4	4	0	0	20	20	0	0
Idaho:	Idaho Falls	<5	<5	10	8	0	0	20	15	0	0
Ill:	Chicago	<5	<5	9	8	0	0	20	15	0	0
Ind:	Indianapolis	<5	<5	10	9	0	0	15	15	0	0
Iowa:	Des Moines	<5	<5	12	10	0	0	20	25	0	0
Kans:	Wichita	<5	<5	11	10	0	0	10	5	0	0
Ky:	Louisville	5		16	16	0	0	10	5	0	0
La:	New Orleans	<5	<5	33	28	0	0	55	40	0	0
Maine:	Portland	<5	<5	14	13	0	0	50	35	0	0
Md:	Baltimore	<5		12	12	0	0	20	15	0	0
Mass:	Boston	<5	<5	15	14	0	0	50	35	0	0
Mich:	Detroit	<5	<5	9	9	0	0	20	15	0	0
	Grand Rapids	<5	<5	12	11	0	0	30	20	0	0
Minn:	Minneapolis	<5	<5	18	17	0	0	25	10	0	0
Miss:	Jackson	5		20	19	0	0	25	20	0	0
Mo:	Kansas	5	<5	13	15	0	0	10	10	0	0
	St. Louis	10	<5	16	16	0	0	20	15	0	0
Mont:	Helena	<5	<5	10	9	0	0	25	15	0	0
Nebr:	Omaha	5	<5	12	11	0	0	20	15	0	0
Nev:	Las Vegas	<5	<5	4	4	0	0	10	10	0	0
N.H:	Manchester	<5	<5	18	15	0	0	75	55	0	0
N.J:	Trenton	<5	<5	11	10	0	0	20	15	0	0
N. Mex:	Albuquerque	<5	<5	7	8	0	0	10	10	0	0
N.Y:	Buffalo	<5	<5	10	9	0	0	25	20	0	0
	New York	<5	<5	14	12	0	0	30	20	0	0
	Syracuse	<5	<5	10	9	0	0	25	20	0	0
N.C:	Charlotte	<5		20	20	0	0	25	20	0	0
N. Dak:	Minot	<5	<5	21	21	0	0	25	25	0	0
Ohio:	Cincinnati	<5	<5	11	11	0	0	15	15	0	0
	Cleveland	<5	<5	11	9	0	0	20	15	0	0
Okla:	Oklahoma City	<5		11	11	0	0	15	10	0	0
Ore:	Portland	<5	<5	11	11	0	0	30	25	0	0
Pa:	Philadelphia	<5	<5	11	10	0	0	20	20	0	0
	Pittsburgh	<5	<5	15	13	0	0	25	20	0	0
P.R:	San Juan	<5		7	6	0	0	20	20	0	0
R.I:	Providence	<5	<5	15	12	0	0	40	30	0	0
S.C:	Charleston	<5	<5	20	20	0	0	50	45	0	0
S. Dak:	Rapid City	5	<5	14	11	0	0	15	10	0	0
Tenn:	Chattanooga	<5		20	19	0	0	25	15	0	0
	Memphis	<5		16	16	0	0	15	10	0	0
Tex:	Austin	<5		5	6	0	0	10	5	0	0
	Dallas	<5		11	11	0	0	15	10	0	0
Utah:	Salt Lake City	<5	<5	9	8	0	0	15	15	0	0
Vt:	Burlington	<5	<5	13	10	0	0	35	25	0	0
Va:	Norfolk	<5		16	16	0	0	20	15	0	0
Wash:	Seattle	<5	<5	19	14	0	0	55	45	0	0
	Spokane	<5	<5	13	11	0	0	30	25	0	0
W. Va:	Charleston	<5		14	14	0	0	15	10	0	0
Wis:	Milwaukee	<5	<5	8	7	0	0	20	20	0	0
Wyo:	Laramie	<5	<5	9	8	0	0	20	10	0	0
Network average		<5	<5	12.5	11.6	0	0	25	20	0	0

* Blank indicates no strontium-89 determinations were made on samples.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, September 1965 and April–September 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
	Sept	Apr	May	June	July	Aug	Sept
Under 10	11	8	10	9	14	15	21
10–19	44	50	38	41	39	40	37
20–29	7	3	12	10	9	7	5
30–39	1	2	3	3	1	1	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, September 1965 and April–September 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
	Sept	Apr	May	June	July	Aug	Sept
Under 50	50	55	51	56	56	56	61
50–99	12	7	11	6	6	6	1
100–149	0	1	1	1	1	1	1
150–199	1	0	0	0	0	0	0

and September 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations *(1)*, averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for September 1965 and April through September 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

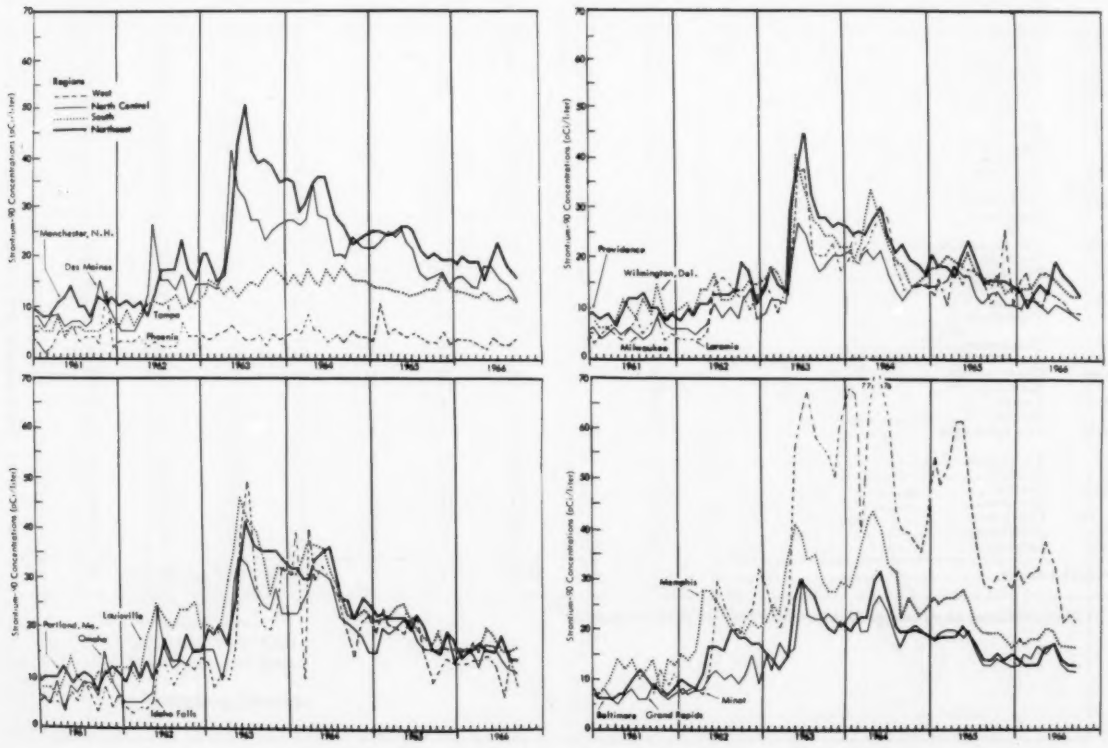

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–September 1966

2. Canadian Milk Network September 1966 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk-sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The September 1966 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from September 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 4. Stable elements and radionuclides in Canadian whole milk, September 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.12	1.6	15.9	34
Edmonton	1.10	1.5	14.4	37
Ft. William	1.06	1.4	16.7	44
Fredericton	1.12	1.5	14.4	38
Halifax	1.14	1.5	16.6	41
Montreal	1.08	1.4	12.3	22
Ottawa	1.17	1.4	8.9	22
Quebec	1.08	1.6	18.2	40
Regina	1.10	1.5	12.4	23
St. John's, Nfld	1.09	1.5	31.7	79
Saskatoon	1.12	1.5	11.2	28
Sault Ste. Marie	1.06	1.5	16.7	36
Toronto	1.15	1.5	5.2	16
Vancouver	1.14	1.5	18.7	87
Windsor	1.10	1.5	6.3	17
Winnipeg	1.08	1.5	10.1	37
Average	1.11	1.5	14.4	38

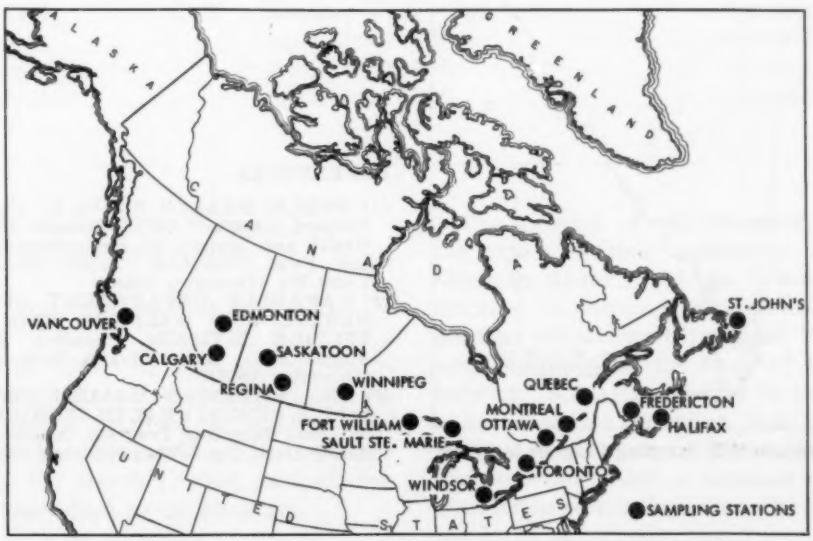

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program September 1966

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).

Figure 4. Pan American Milk Sampling Program locations

Table 5 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations for September 1966.

Table 5. Stable element and radionuclide concentrations in PAHO milk, September 1966 [a]

Sampling station	Number of samples	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:					
Santiago	4	1.16	1.60	2	6
Colombia:					
Bogota	4	1.16	1.46	3	5
Ecuador:					
Guayaquil	4	1.10	1.57	2	5
Jamaica:					
Kingston	NS				
Mandeville	NS				
Montego Bay	1	1.21	1.31	13	300
Venezuela:					
Caracas	1	1.10	1.49	6	<5
February, 1966	1	1.10	1.38	4	20
Canal Zone:					
Cristobal	1	—	—	4	15
Puerto Rico:					
San Juan	1	—	—	6	20

[a] Strontium-89 determinations were less than 5 pCi/liter; iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples.
NS, no sample collected.

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(1) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1966. Division of Radiological Health and Division of Environmental Engineering and Food Protection. Radiol Health Data Rep 7:698–701 (December 1966).

(2) CANADIAN DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(3) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7–704 (December 1966).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to a state of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	April–June 1966	December 1966
Colorado	January 1965–June 1966	October 1966
Connecticut	April–June 1966	November 1966
Florida	April–June 1966	October 1966
Indiana	April–June 1966	November 1966
Michigan	January–June 1966	November 1966
Minnesota	April–June 1966	November 1966
New York	January–June 1966	November 1966
Oregon	April–June 1966	December 1966
Pennsylvania	April–June 1966	November 1966
Washington	April–June 1966	December 1966

1. Oklahoma Milk Network July–September 1966

Oklahoma State Department of Health [1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium–137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 1. Of the 10 milksheds in the State of Oklahoma, 5 were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the iodine–131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a par-

[1] Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

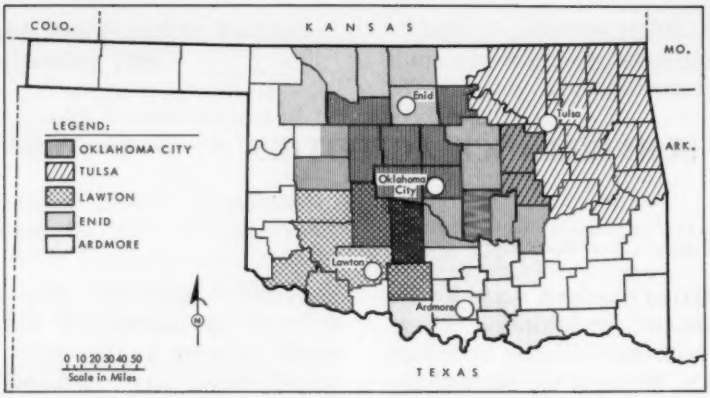

Figure 1. Oklahoma milkshed sampling areas

ticular processing plant may not coincide exactly with that shown in figure 1, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine–131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample milk from each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The ion exchange method of analysis used is similar to that recently published by the Public Health Service (*1*), but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory. Details of the procedure used were published earlier (*2*).

Table 1 gives the cesium–137 concentrations in Oklahoma milk for the period of July through September 1966. Iodine–131 was found in only three samples during this period. These concentrations are shown in table 2.

Table 1. Concentration of cesium-137 in Oklahoma milk July–September 1966

Sampling date		Sampling location				
		Oklahoma City (pCi/liter)	Enid (pCi/liter)	Tulsa (pCi/liter)	Lawton (pCi/liter)	Ardmore (pCi/liter)
July	4	24 • 15	NS	14	11	NS
	11	ND • 13	9	21	ND	17
	18	23 • 22	30	35	22	23
	25	NS • 23	25	30	21	24
August	1	ND • 11	ND	18	ND	ND
	8	32 • 24	24	25	22	23
	15	27 • 21	21	28	23	18
	22	26 • 27	NS	23	27	25
	29	23 • 18	15	23	26	20
September	5	19 • NS	13	25	NS	20
	12	NS • NS	13	32	17	20
	19	20 • 16	NS	19	24	19
	26	NS • 20	NS	NS	NS	NS

• Samples split with PHS Pasteurized Milk Network.
NS, no sample collected
ND, not detectable

Table 2. Concentration of iodine-131 in Oklahoma milk July–September 1966

Date 1966	Sampling station	Concentration (pCi/liter)
July 25	Ardmore	7
August 15	Oklahoma City •	6
September 12	Tulsa	45

• Samples split with PHS Pasteurized Milk Network.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
March–July 1965	October 1965
August–December 1965	April 1966
January–March 1966	July 1966
April–June 1966	October 1966

2. Texas Milk Network July–September 1966

Texas State Department of Health [2]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "standby" stations have been supplied sample containers and shipping instructions and can be activated immediately if needed. The "active" and "standby" station locations, shown in figure 2, were chosen to give maximum geographical and population coverage.

[2] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

Samples are routinely analyzed for strontium–89 and strontium–90 by a chemical-separation technique employing ion exchange columns (*3*).

Potassium–40, iodine–131, and barium–140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*4*).

Table 3 presents the July through September 1966 radionuclide concentrations in Texas milk. During this time, strontium–89 and barium–140 concentrations were below detectable levels. Strontium–90 and cesium–137 concentrations are shown graphically in figure 3 to indicate general trends.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1964 Summary	June 1965
January–March 1965	October 1965
April–December 1965	April 1966
January–March 1966	July 1966
April–June 1966	October 1966

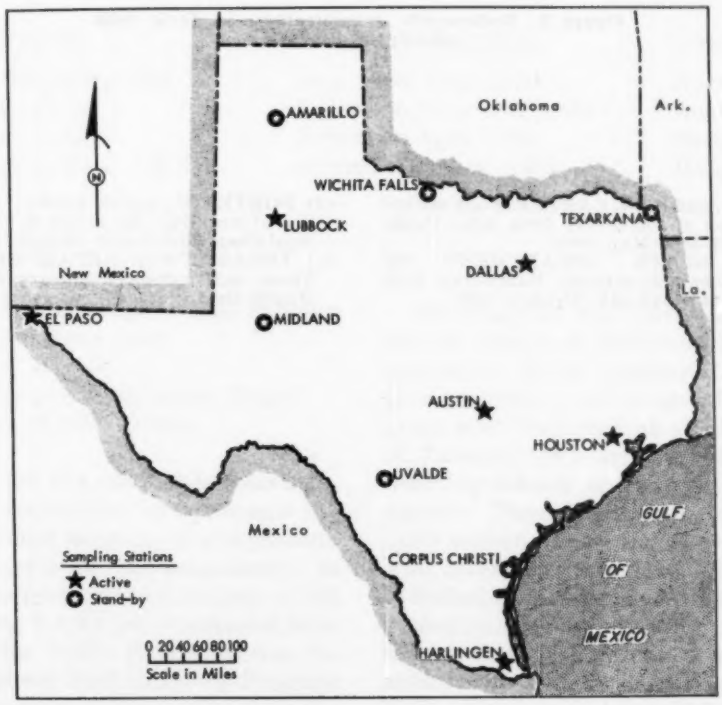

Figure 2. Texas milk sampling stations

Table 3. Radionuclide concentrations in Texas milk network, July–September 1966

Sampling location	Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Austin	1,210	NS	1,370	5	NS	4	ND	NS	6	10	NS	5
Fort Worth	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
El Paso	1,270	1,250	1,300	4	2	3	ND	ND	ND	5	5	5
Harlingen	1,300	1,270	1,360	2	4	4	4	ND	ND	10	5	5
Houston	1,290	NS	NS	8	NS	NS	5	NS	NS	NS	NS	NS
Lubbock	1,300	1,220	1,340	5	4	5	20	ND	ND	20	10	10
San Antonio	NS	1,230	1,330	NS	4	3	NS	5	4	NS	10	5
Average	1,275	1,245	1,340	4.8	3.5	3.8	6	1.3	2	14	7.5	6

NS, no sample collected.
ND, below detectable limits.

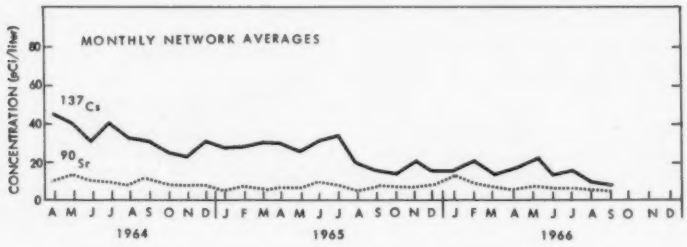

Figure 3. Radionuclide concentrations in Texas milk 1964–September 1966

REFERENCES

(*1*) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine–131 from milk. Public Health Rep 80:453–456 (May 1965).

(*2*) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma milk network, March–July 1965. Radiol Health Data 6:540–541 (October 1965).

(*3*) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by ion–exchange method. Anal Chem 36:676–678 (March 1964).

(*4*) TEXAS STATE DEPARTMENT OF HEALTH. Texas milk network, January–March 1965. Radiol Health Data 6:541–542 (October 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reporting routinely include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
Connecticut Standard Diet	July 1965–June 1966	November 1966
Teenage Diet, FDA	February–November 1965	August 1966
Tri-City Diet, HASL	February–April 1966	December 1966
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

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1. Radionuclides in Institutional Diet Samples April–June 1966

National Center for Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily intakes of teenage girls and children from 9 to 12 years of age were

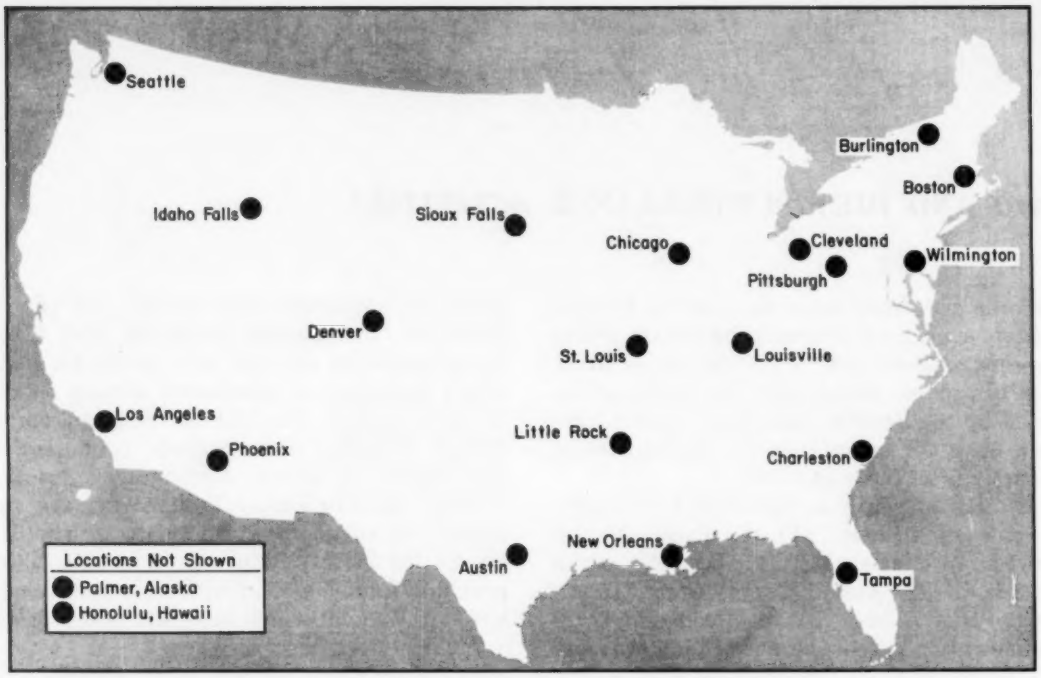

Figure 1. Institutional diet sampling locations as of July 1965

comparable, while teenage boys consumed 20 percent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented elsewhere (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June 1966, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of strontium–89, strontium–90, cesium–137, and radium–226 are expressed as pCi/kg of diet. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period, where applicable.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. For the purpose of obtaining dietary intakes, "less than" 5 pCi/kg of strontium–89 was interpreted as 2.5 pCi/kg. The average food consumption rate during this period was 1.76 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

Strontium–90 dietary intake during this period averaged 19 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*5*). Cesium–137 intakes averaged 60 pCi/day during this period. Strontium–89, barium–140, and iodine–131 concentrations were generally below detectable levels.

Previous coverage in Radiological Health Data and Reports:

Period	Issue
January–March 1964	October 1964
April–June 1964	January 1965
July–September 1964	April 1965
October–December 1964	July 1965
Annual average 1964	July 1965
January–March 1965	October 1965
April–June 1965	February 1966
July–September 1965	May 1966
October–December 1965	July 1966
Annual average 1965	July 1966
January–March 1966	October 1966

Table 1. Stable element and radionuclide concentrations in institutional total diets of children (9–12 years of age) April–June 1966 [a]

Location of institution	Month 1966	Stable element, g/kg of diet		Radionuclide concentration, pCi/kg of diet			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	April	0.5	0.8	<5	11	35	0.3
	May	0.6	0.8	<5	21	40	1.9
	June	0.8	1.0	<5	12	35	1.1
Ariz: Phoenix	April	0.5	0.8	<5	7	20	0.7
	May	0.6	1.0	<5	11	20	1.9
	June	0.6	1.3	<5	12	30	0.7
Ark: Little Rock	April	0.6	1.4	<5	12	25	1.3
	May	0.5	1.4	<5	14	30	0.8
	June	0.5	1.5	10	18	25	1.0
Calif: Los Angeles	April	0.9	1.4	<5	7	20	2.4
	May	1.1	1.4	<5	12	25	3.0
	June	0.9	1.5	<5	6	25	1.0
Colo: Denver	April	0.8	1.1	<5	11	30	0.2
	May	0.8	1.3	<5	16	30	0.2
	June	0.9	1.4	<5	8	20	1.0
Del: Wilmington	April	0.6	1.6	<5	9	25	0.6
	May	0.7	1.5	<5	10	25	0.3
	June	0.7	1.7	<5	11	25	0.7
Fla: Tampa	April	0.9	1.7	<5	11	85	2.7
	May	0.6	1.3	<5	9	55	1.1
	June	0.6	1.6	<5	12	80	3.4
Hawaii: Honolulu	April	0.5	1.2	<5	5	40	0.4
	May	0.4	1.2	<5	5	30	0.7
	June	0.4	1.3	<5	5	35	0.4
Idaho: Idaho Falls	April	0.7	1.5	<5	8	30	0.8
	May	1.2	1.5	<5	25	30	0.1
	June	0.7	1.4	<5	6	30	0.7
Ill: Chicago	April	0.7	1.5	<5	8	35	0.6
	May	0.7	1.4	<5	8	40	0.7
	June	0.7	1.4	5	12	30	0.2
Ky: Louisville	April	0.9	1.7	<5	13	25	2.2
	May	0.8	1.9	<5	16	55	1.1
	June	1.0	1.8	10	19	30	2.9
La: New Orleans	April	0.8	1.5	<5	18	40	0.8
	May	0.8	1.6	<5	21	35	0.6
	June	0.6	1.3	<5	22	45	0.8
Mass: Boston	April	0.5	1.3	<5	8	25	0.5
	May	0.6	1.5	<5	7	35	0.7
	June	0.5	1.3	<5	9	30	0.5
Mo: St. Louis	April	0.7	1.5	<5	10	30	0.6
	May	0.8	1.5	<5	12	30	0.7
	June	0.8	1.6	30	17	35	0.2
Ohio: Cleveland	April	0.7	1.6	<5	10	80	0.9
	May	0.6	1.6	<5	7	40	0.7
	June	0.7	1.6	<5	11	30	1.1
Pa: Pittsburgh	April	0.6	1.4	<5	10	35	0.7
	May	0.6	1.2	<5	9	40	1.0
	June	0.6	1.4	<5	11	25	0.7
S.C: Charleston	April	0.7	1.2	<5	13	25	1.3
	May	0.6	1.5	<5	12	25	1.1
	June	0.6	1.3	10	14	50	1.5
S. Dak: Sioux Falls	April	0.8	1.7	<5	17	65	0.8
	May	0.8	1.5	<5	14	40	0.7
	June	1.0	1.7	10	12	35	0.8
Tex: Austin	April	0.5	1.3	<5	6	25	1.6
	May	0.6	1.2	<5	6	15	1.0
	June	0.5	1.2	<5	10	25	1.0
Vt: Burlington	April	0.6	1.6	<5	11	50	0.4
	May	0.7	1.6	<5	16	55	0.6
	June	0.6	1.5	<5	13	40	0.5
Wash: Seattle	April	0.8	1.6	<5	20	65	0.6
	May	0.8	1.7	<5	18	40	0.3
	June	0.8	1.4	<5	29	50	1.3
Institutional average	April	0.7	1.4	<5	11	40	1.0
	May	0.7	1.4	<5	13	35	0.9
	June	0.7	1.4	5	13	35	1.0

[a] During the second quarter of 1966, both iodine-131 and barium-140 concentrations were below detectable levels at all institutions except for following:
Del: Wilmington June 1966 10 pCi/kg, iodine-131
S. Dak: Sioux Falls June 1966 20 pCi/kg, iodine-131

Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9–12 years of age) April–June 1966

Location of institution	Month 1966	Total weight (kg/day)	Stable element intake, g/day		Radionuclide intake, pCi/day			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	April [a]	1.89	0.9	1.5	5	21	65	0.6
	May [a]	1.38	0.8	1.1	5	29	55	2.6
	June [a]	1.71	1.4	1.7	5	21	60	1.9
Ariz: Phoenix	April	1.96	1.0	1.6	5	14	40	1.4
	May	2.15	1.3	2.2	5	24	45	4.1
	June	1.71	1.0	2.2	5	21	50	1.2
Ark: Little Rock	April	1.19	0.7	1.7	5	14	30	1.5
	May	1.96	1.0	2.7	5	27	60	1.6
	June	1.20	0.6	1.8	10	22	30	1.2
Calif: Los Angeles	April	2.04	1.8	2.9	5	14	40	4.9
	May	1.88	2.1	2.6	5	23	45	5.6
	June	2.03	1.8	3.0	5	12	50	2.0
Colo: Denver	April	2.13	1.7	2.3	5	23	65	0.4
	May	2.07	1.7	2.7	5	33	60	0.4
	June	2.12	1.9	3.0	5	17	40	2.1
Del: Wilmington	April	2.11	1.3	3.4	5	19	55	1.3
	May	1.95	1.4	2.9	5	20	50	0.6
	June	1.96	1.4	3.3	5	22	50	1.4
Fla: Tampa	April	1.94	1.7	3.3	5	21	165	5.2
	May	1.55	0.9	2.0	5	14	85	1.7
	June	1.64	1.0	2.6	5	20	130	5.6
Hawaii: Honolulu	April	2.08	1.0	2.5	5	10	85	0.8
	May	2.08	0.8	2.5	5	10	60	1.5
	June	2.10	0.8	2.7	5	10	75	0.8
Idaho: Idaho Falls	April [b]	1.77	1.2	2.7	5	14	55	1.4
	May [b]	1.90	2.3	2.8	5	48	55	0.2
	June [b]	1.47	1.0	2.1	5	9	45	1.0
Ill: Chicago	April	1.36	1.0	2.0	5	11	50	0.8
	May [b]	1.55	1.1	2.2	5	12	60	1.1
	June [b]	1.63	1.1	2.3	10	20	50	0.3
Ky: Louisville	April	1.26	1.1	2.1	5	16	30	2.8
	May	1.34	1.1	2.5	5	21	75	1.5
	June	1.31	1.3	2.4	15	25	40	3.8
La: New Orleans	April [a]	1.86	1.5	2.8	5	33	75	1.5
	May	2.25	1.9	3.8	5	49	80	1.4
	June	1.48	0.9	1.9	5	33	65	1.2
Mass: Boston	April	2.37	1.2	3.1	5	19	60	1.2
	May	2.56	1.5	3.8	5	18	90	1.8
	June	2.35	1.2	3.1	5	21	70	1.2
Mo: St. Louis	April	1.92	1.3	2.9	5	19	60	1.2
	May	2.40	1.9	3.6	5	29	70	1.7
	June [b]	2.47	2.0	4.0	75	42	85	0.5
Ohio: Cleveland	April	1.19	0.8	1.9	5	12	95	1.1
	May	1.50	0.9	2.4	5	10	60	1.0
	June	1.09	0.8	1.7	5	12	35	1.2
Pa: Pittsburgh	April [b]	2.30	1.4	3.2	5	23	80	1.6
	May [b]	2.31	1.4	2.8	5	21	90	2.3
	June [b]	2.43	1.5	3.4	5	27	60	1.7
S.C: Charleston	April	1.45	1.0	1.7	5	19	35	1.9
	May	1.86	1.1	2.8	5	22	45	2.0
	June	1.38	0.8	1.8	15	19	70	2.1
S. Dak: Sioux Falls	April	1.68	1.3	2.9	5	29	110	1.3
	May	1.70	1.4	2.6	5	24	70	1.2
	June	1.61	1.6	2.7	15	19	55	1.3
Tex: Austin	April	1.70	0.8	2.2	5	10	40	2.7
	May	1.65	1.0	2.0	5	10	25	1.6
	June	1.68	0.8	2.0	5	17	40	1.7
Vt: Burlington	April	1.22	0.7	2.0	5	13	60	0.5
	May	1.28	0.9	2.0	5	20	70	0.8
	June	1.19	0.7	1.8	5	15	50	0.6
Wash: Seattle	April [b]	1.43	1.1	2.3	5	29	95	0.9
	May [b]	1.50	1.2	2.6	5	27	60	0.4
	June [b]	1.63	1.3	2.3	5	45	80	2.1
Institutional average	April	1.72	1.2	2.4	5	16	65	1.8
	May	1.89	1.3	2.7	5	22	60	1.8
	June	1.66	1.1	2.4	5	19	55	1.8

[a] Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children under 9 years of age.

[b] Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children over 12 years of age.

2. Estimated daily intake of radionuclides in California diets January–April 1966

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*6*).

Recognizing that a standard or typical diet does not exist, because of variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the house diet of a hospital in each of the 20 geographic areas of interest (figure 2).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as reasonably representative as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Figure 2. California diet sampling stations

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

Analytical procedures

After weighing at the Laboratory, each sample is homogenized and gamma-scanned, then dried and ashed prior to analysis for strontium–89, strontium–90, radium–226, and stable calcium, strontium, and sodium.

Table 3. Estimated daily intake of radionuclides in California diets, January–February 1966 [a]

City	Consumption (kg/capita • day) [b]	Intake, pCi/capita • day						Intake, g/capita • day			
		Strontium-90	Radium-226	Cesium-137	Zirconium-95	Manganese-54	Cerium-141/144	Potassium [c]	Sodium	Calcium	Stable strontium
Bakersfield	2.5	10	0.2	26	5	0	0	3.0	4.4	1.3	0.005
Berkeley	2.4	7	1.0	42	0	0	10	2.6	5.1	0.6	0.004
Bishop	2.0	9	1.0	32	0	1	22	2.8	4.0	1.2	0.003
Brawley	2.2	12	0.4	38	4	0	3	2.8	3.8	1.3	0.004
Crescent City	2.1	29	0.8	78	6	0	0	2.7	3.7	1.0	0.005
Eureka	2.5	16	0.6	52	3	0	3	3.2	2.4	1.8	0.003
Fresno	2.4	11	0.7	44	0	0	4	2.4	4.0	1.0	0.006
Los Angeles	2.2	13	0.7	38	5	0	0	2.8	5.2	1.0	0.005
Needles	2.1	11	0.7	40	1	0	5	3.0	4.3	1.0	0.009
Quincy	1.4	8	0.2	25	0	0	1	1.7	2.6	0.5	0.003
Redding	2.1	16	0.9	58	4	0	2	2.6	3.8	1.3	0.006
Sacramento	2.6	17	2.8	46	2	0	8	4.4	7.3	1.8	0.003
Salinas	2.3	7	0.7	51	2	0	0	3.0	5.7	0.8	0.002
San Bernardino	1.1	3	0.9	14	2	0	2	1.8	2.7	1.0	0.001
San Diego	2.0	3	0.5	54	0	0	0	2.6	3.1	0.9	0.003
San Luis Obispo	1.3	6	0.5	27	4	0	2	1.1	2.1	0.7	0.002
Santa Barbara	2.2	11	0.6	70	5	0	12	2.8	3.7	1.0	0.003
Santa Rosa	2.3	8	0.6	50	2	0	13	2.4	3.0	1.1	0.003
Susanville	1.5	6	0.4	33	3	0	7	1.8	3.2	0.6	0.001
Ukiah	2.5	13	0.4	52	13	27	0	3.0	4.0	1.4	0.005

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] National potassium contains 0.0119 percent radioactive potassium-40.

Table 4. Estimated daily intake of radionuclides in California diets, March–April 1966 [a]

City	Consumption (kg/capita • day) [b]	Intake, pCi/capita • day						Intake, g/capita • day			
		Strontium-90	Radium-226	Cesium-137	Zirconium-95	Manganese-54	Cerium-141/144	Potassium [c]	Sodium	Calcium	Stable strontium
Bakersfield	1.6	11	0.1	11	0	0	0	3.3	6.4	0.9	0.004
Berkeley	2.3	12	0.8	41	3	0	5	3.4	3.8	1.3	0.002
Bishop	1.9	8	0.6	29	0	0	0	1.9	3.4	0.8	0.002
Brawley	1.9	11	0.6	25	2	0	0	2.5	3.4	0.9	0.003
Crescent City	2.1	18	0.3	49	2	0	0	2.2	4.0	0.9	0.001
Eureka	1.9	10	0.7	26	3	0	16	2.0	3.3	0.7	0.002
Fresno	1.5	13	0.6	38	0	0	6	1.9	2.4	0.7	0.001
Los Angeles	2.0	8	1.4	46	5	0	3	2.5	3.8	1.0	0.003
Needles	1.8	9	0.5	24	1	0	0	2.3	3.4	0.8	0.002
Quincy	1.4	9	0.5	23	1	0	6	1.7	2.7	0.5	0.002
Redding	2.4	13	1.0	40	3	0	3	2.2	4.4	1.0	0.001
Sacramento	2.2	10	1.2	27	0	0	0	2.1	3.7	0.9	0.002
Salinas	2.5	8	0.9	32	0	0	15	3.0	5.4	1.0	0.002
San Bernardino	1.8	7	0.5	17	2	0	12	2.2	3.3	0.8	0.002
San Diego	1.8	8	0.3	23	0	0		2.4	2.9	0.3	0.003
San Luis Obispo	1.3	10	0.8	22	0	0	0	1.8	3.4	1.0	0.003
Santa Barbara	2.1	14	0.5	27	1	0	0	2.5	3.8	1.1	0.003
Santa Rosa	2.1	11	0.7	32	2	0	0	1.8	2.4	1.1	0.002
Susanville	1.9	10	0.8	38	1	0	0	2.1	3.9	0.6	0.002
Ukiah	2.2	9	0.6	61	0	0	3	2.4	2.6	0.9	<0.001

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] National potassium contains 0.0119 percent radioactive potassium-40.

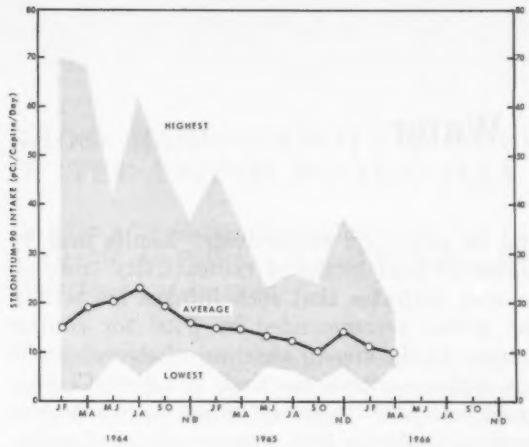

Figure 3. Averages and ranges of daily strontium–90 intake in California diets

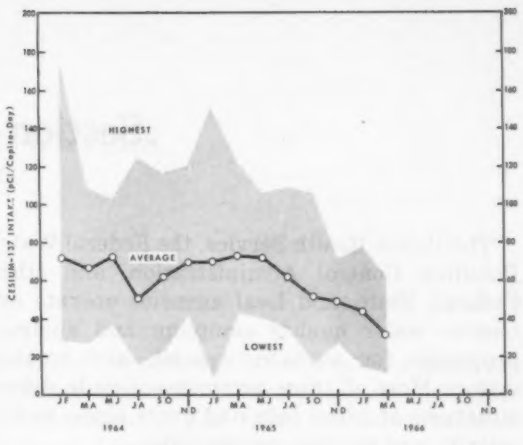

Figure 4. Averages and ranges of daily cesium–137 intake in California diets

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the California State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 3 (January–February 1966) and table 4 (March–April 1966).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. Strontium–90 intake in the California diet for the January–February 1966 period varied from 3 to 29 pCi/capita • day, with an average of 11 pCi/capita • day. Cesium–137 intake varied from 14 to 78 pCi/capita • day with an average of 44 pCi/capita • day. For the March–April 1966 sampling period, the strontium–90 intake varied from 7 to 18 pCi/capita • day, with an average of 10 pCi/capita • day. Cesium–137 intake varied from 11 to 61 pCi/capita • day, with an average of 32 pCi/capita • day. A summary of strontium–90 and cesium–137 intake trends in California diets from January 1964 through April 1966 is given in figures 3 and 4.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1964	March and April 1965
July–October 1964	September 1965
November–December 1964	December 1965
January–April 1965	March 1966
May–August 1965	June 1966
September–December 1965	September 1966

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Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

Program	Period reported	Last presented
California Water Sampling Program	July–December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

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GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JULY 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of Radiological Health Data and Reports.

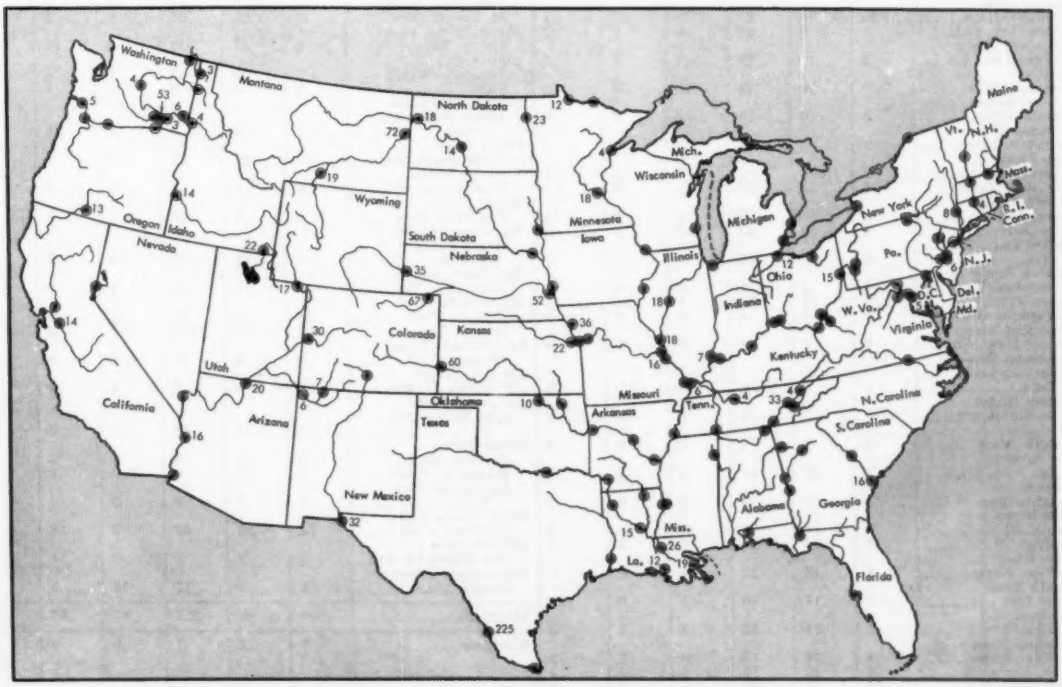

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, July 1966

Complete data and exact sampling locations are published in annual compilations (*1–6*) and are available on request.

Special note is made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both June and July, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

South Platte River: Julesburg, Colo.
Arkansas River: Coolidge Kans.

Table 1. Radioactivity in raw surface waters, July 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	1	6	7	0	1	1
Arkansas River:						
Coolidge, Kans.	29	31	60	6	15	21
Ponca City, Okla.	1	9	10	0	2	2
Atchafalaya River:						
Morgan City, La.	2	10	12	<1	1	1
Bear River:						
Preston, Idaho	2	20	22	0	6	6
Big Horn River:						
Hardin, Mont.	3	16	19	1	7	8
Clearwater River:						
Lewiston, Idaho	1	3	4	0	0	0
Clinch River:						
Clinton, Tenn	0	4	4	0	0	0
Kingston, Tenn.[a]	16	17	33	<1	0	<1
Colorado River:						
Loma, Colo.	15	15	30	5	9	14
Page, Ariz.	0	20	20	0	5	5
Parker Dam, Calif.-Ariz.	0	16	16	0	5	5
Columbia River:						
Wenatchee, Wash.	0	4	4	0	0	0
Pasco, Wash.[a]	22	31	53	1	<1	1
Clatskanie, Ore.	0	5	5	0	0	0
Connecticut River:						
Enfield Dam, Conn.	0	4	4	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	1	3	4	0	0	0
Delaware River:						
Philadelphia, Pa.	1	5	6	0	0	0
Great Lakes:						
Duluth, Minn.	0	4	4	0	0	0
Green River:						
Dutch John, Utah	1	16	17	0	2	2
Hudson River:						
Poughkeepsie, N.Y.	2	6	8	0	0	0
Illinois River:						
Peoria, Ill.	2	16	18	0	2	2
Grafton, Ill.	2	16	18	0	3	3
Kansas River:						
DeSoto, Kans.	4	18	22	1	2	3
Klamath River:						
Keno, Ore.	1	12	13	<1	0	<1
Maumee River:						
Toledo, Ohio	1	11	12	1	2	3
Mississippi River:						
St. Paul, Minn.	2	16	18	0	3	3
E. St. Louis, Ill.	4	12	16	2	2	4
New Roads, La.	15	11	26	4	2	6
New Orleans, La.	5	14	19	4	3	7
Missouri River:						
Williston, N. Dak.	6	12	18	2	2	4
Bismarck, N. Dak.	1	13	14	0	2	2
St. Joseph, Mo.	17	19	36	6	3	9
North Platte River:						
Henry, Nebr.	8	27	35	2	12	14
Ohio River:						
Toronto, Ohio	5	10	15	1	0	1
Cairo, Ill.	1	5	6	0	1	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	3	3	0	<1	<1
Platte River:						
Plattsmouth, Nebr.	31	21	52	7	4	11
Potomac River:						
Washington, D.C.	0	5	5	0	0	0
Rainy River:						
Baudette, Minn.	3	9	12	<1	0	<1
Red River, North:						
Grand Forks, N. Dak.	1	22	23	0	2	2
Red River, South:						
Alexandria, La.	3	12	15	1	0	1
Rio Grande:						
El Paso, Tex.	20	12	32	8	2	10
Laredo, Tex.	206	19	225	57	4	61
San Joaquin River:						
Vernalis, Calif.	6	8	14	2	3	5
San Juan River:						
Shiprock, N. Mex.	0	6	6	2	12	14
Savannah River:						
Port Wentworth, Ga.[a]	4	12	16	<1	0	<1
Snake River:						
Payette, Idaho	3	11	14	1	5	6
Wawawai, Wash.	0	6	6	0	1	1
Ice Harbor Dam, Wash.	1	2	3	0	1	1
South Platte River:						
Julesburg, Colo.	11	56	67	2	30	32
Wabash River:						
New Harmony, Ind.	0	7	7	0	1	1
Yellowstone River:						
Sidney, Mont.	66	6	72	19	2	21
Maximum	206	56	225	57	30	61
Minimum	0	2	3	0	0	0

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility, in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

The following stations dropped below 15 pCi/liter of alpha radioactivity on either suspended or dissolved solids:

Atchafalaya River: Morgan City, La.
North Platte River: Henry, Nebr.

The following stations showed an increase in alpha radioactivity to values of more than 15 pCi/liter on suspended solids:

Platte River: Plattsmouth, Nebr.
Rio Grande: Laredo, Tex.
Yellowstone River: Sidney, Mont.

The high alpha and beta radioactivity for Laredo, Tex., was entirely due to high turbidity in the sample collected on July 5, 1966. The remaining samples for that month showed only low levels of radioactivity.

During July the beta radioactivity at Pasco, Wash., on the Columbia River showed unusually low values. This was a result of reactor shutdown.

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RADIOACTIVITY IN MINNESOTA MUNICIPAL WATER SUPPLIES JANUARY–JUNE 1966[1]

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). Grab samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul; and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

[1] Data and information from "Survey of Environmental Radioactivity, January–June 1966." State of Minnesota Department of Public Health, University Campus, Minneapolis, Minn. 55440. Publication No. C00–651–33.

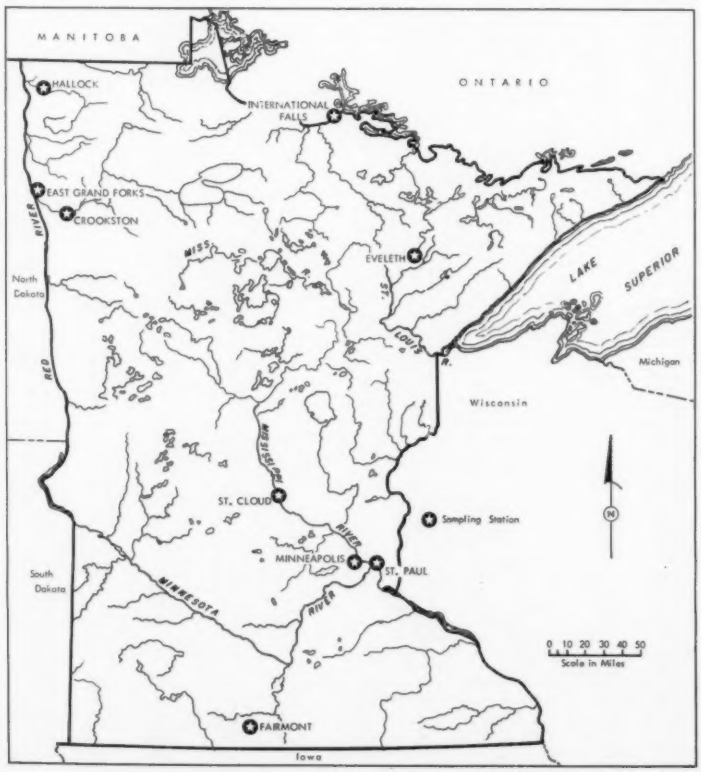

Figure 1. Minnesota surface water sampling locations

The samples are forwarded to the Division's laboratory, where they are analyzed for gross beta activity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for beta activity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta activity in Minnesota municipal water supplies from January through June 1966. In averaging, samples reported to contain nondetectable concentrations were assigned an arbitrary concentration of 7 pCi/liter.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 4 to 96 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*). Treated water in most cases contained less beta activity than the corresponding raw water.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
December 1962–June 1963	November 1963
July–December 1963	June 1964
January–June 1964	January 1965
July–December 1964	August 1965
January–June 1965	February 1966
July–December 1965	July 1966

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 1. Total beta concentrations in Minnesota raw and treated water supplies January–June 1966

Town and water source	Average concentrations, pCi/liter						
	Type of water	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	19	96	33	21	17	23
	Treated	37	7	23	15	21	26
East Grand Forks, Red Lake River	Raw	28	25	18	15	20	23
	Treated	14	10	10	10	13	12
Eveleth, St. Mary's Lake	Raw	38	16	16	19	11	13
	Treated	20	13	14	14	14	14
Fairmont, Budd Lake	Raw	26	23	14	5	4	20
	Treated	10	7	8	6	6	8
Hallock, Two Rivers South Fork	Raw	51	31	22	18	24	29
	Treated	7	11	10	10	9	11
International Falls, Rainy River	Raw	7	7	11	11	9	10
	Treated	17	19	10	10	9	9
Minneapolis Tap Water	Treated	11	8	11	6	7	7
St. Cloud, Mississippi River	Raw	7	30	13	14	13	15
	Treated	17	7	9	7	4	6
St. Paul, Vadnais Chain of Lakes	Raw	24	16	15	14	14	17
	Treated	14	8	9	12	8	8

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to the programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*:

Network	Period	Issue
HASL Fallout Network	July–December 1965	September 1966

1. Radiation Surveillance Network September 1966

National Center for Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during September 1966. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2. Gamma-ray spectroscopy was performed on 307 air samples. No fresh fission products were identified.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, September 1966

Station location		Number of samples		Air surveillance gross beta activity, pCi/m³			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	28	5	0.20	<0.10	<0.11	Nov 66	63	<13
Alaska:	Adak	30		<0.10	<0.10	<0.10	June 66	[b]	
	Anchorage	18	8	<0.10	<0.10	<0.10	Dec 66	54	<11
	Attu Island	30		<0.10	<0.10	<0.10	July 66	[b]	
	Fairbanks	16	1	<0.10	<0.10	<0.10	Apr 66	1	<1
	Juneau	19	19	<0.10	<0.10	<0.10	Jul 65	591	<118
	Kodiak	3		<0.10	<0.10	<0.10	May 66	[b]	
	Nome	18		<0.10	<0.10	<0.10	Sept 66	[b]	
	Pt. Barrow	14		<0.10	<0.10	<0.10	Aug 66	[b]	
	St. Paul Island	30		<0.10	<0.10	<0.10	Oct 66	[b]	
Ariz:	Phoenix	24		0.23	<0.10	<0.11	July 65	[b]	
Ark:	Little Rock	27	2	<0.10	<0.10	<0.10	Dec 66	14	<3
Calif:	Berkeley	20	1	<0.10	<0.10	<0.10	May 66	3	<1
	Los Angeles	19	2	<0.10	<0.10	<0.10	Sept 66	7	<1
C.Z:	Ancón	17		<0.10	<0.10	<0.10	May 66	[b]	
Colo:	Denver	30	4	<0.10	<0.10	<0.10	May 66	42	<8
Conn:	Hartford	30	6	<0.10	<0.10	<0.10	Jan 67	98	<20
Del:	Dover	21		<0.10	<0.10	<0.10	Nov 66	[b]	
D.C:	Washington	22	7	<0.10	<0.10	<0.10	Aug 66	178	<36
Fla:	Jacksonville	27	13	<0.10	<0.10	<0.10	Dec 66	173	<35
	Miami	28	13	<0.10	<0.10	<0.10	Jan 67	233	<47
Ga:	Atlanta	[c]	8				Oct 66	66	<13
Guam:	Agana	30		<0.10	<0.10	<0.10	Nov 66	[b]	
Hawaii:	Honolulu	30		<0.10	<0.10	<0.10	July 66	[b]	
Idaho:	Boise	29		<0.10	<0.10	<0.10	July 66	[b]	
Ill:	Springfield	30	6	0.13	<0.10	<0.10	Aug 66	101	<20
Ind:	Indianapolis	30	9	0.11	<0.10	<0.10	Oct 66	148	<30
Iowa:	Iowa City	26	2	<0.10	<0.10	<0.10	May 66	9	<2
Kans:	Topeka	30	5	<0.10	<0.10	<0.10	Dec 66	27	<6
Ky:	Frankfort	28	7	<0.10	<0.10	<0.10	Aug 66	44	<9
La:	New Orleans	30	10	<0.10	<0.10	<0.10	Aug 66	205	<41
Maine:	Augusta	30	6	<0.10	<0.10	<0.10	Sept 66	96	<19
	Presque Isle	24	7	<0.10	<0.10	<0.10	May 66	71	<14
Md:	Baltimore	20	8	<0.10	<0.10	<0.10	Jan 67	71	<14
	Rockville	15		<0.10	<0.10	<0.10	July 66	[b]	
Mass:	Lawrence	29	8	<0.10	<0.10	<0.10	Nov 66	145	<29
	Winchester	29	8	<0.10	<0.10	<0.10	June 66	80	<16
Mich:	Lansing	30	7	<0.10	<0.10	<0.10	July 66	32	<7
Minn:	Minneapolis	21	4	<0.10	<0.10	<0.10	Nov 66	60	<12
Miss:	Jackson	29	7	<0.10	<0.10	<0.10	Sept 66	95	<19
Mo:	Jefferson City	30	6	<0.10	<0.10	<0.10	Oct 66	25	<5
Mont:	Helena	30	4	<0.10	<0.10	<0.10	June 66	8	<2
Nebr:	Lincoln	15	6	0.35	<0.10	<0.13	Oct 66	102	<21
Nev:	Las Vegas	22		0.13	<0.10	<0.10	Apr 66	[b]	
N.H:	Concord	18		<0.10	<0.10	<0.10	Aug 66	[b]	
N.J:	Trenton	29	9	<0.10	<0.10	<0.10	Sept 66	51	<10
N. Mex:	Santa Fe	28	5	<0.10	<0.10	<0.10	June 66	16	<3
N.Y:	Albany	20	7	<0.10	<0.10	<0.10	Oct 66	71	<14
	Buffalo	27		<0.10	<0.10	<0.10	May 66	[b]	
	New York	29		<0.10	<0.10	<0.10	June 66	[b]	
N.C:	Gastonia	30	7	<0.10	<0.10	<0.10	May 66	101	<20
N. Dak:	Bismarck	29	4	0.11	<0.10	<0.10	Aug 66	19	<4
Ohio:	Cincinnati	21		<0.10	<0.10	<0.10	Nov 66	[b]	
	Columbus	29	6	0.12	<0.10	<0.10	Sept 66	106	<21
	Painesville	27	7	<0.10	<0.10	<0.10	Jan 67	75	<15
Okla:	Oklahoma City	27	7	<0.10	<0.10	<0.10	July 66	56	<11
	Ponca City	29	8	<0.10	<0.10	<0.10	Jan 67	111	<22
Ore:	Portland	30	8	<0.10	<0.10	<0.10	Oct 66	37	<7
Pa:	Harrisburg	29	2	<0.10	<0.10	<0.10	Oct 66	41	<8
P.R:	San Juan	24	8	<0.10	<0.10	<0.10	Sept 66	216	<43
R.I:	Providence	28	6	<0.10	<0.10	<0.10	July 66	126	<25
S.C:	Columbia	27	5	<0.10	<0.10	<0.10	June 66	43	<9
S. Dak:	Pierre	29	7	<0.10	<0.10	<0.10	July 65	34	<7
Tenn:	Nashville	29	10	<0.10	<0.10	<0.10	July 66	77	<15
Tex:	Austin	29	5	<0.10	<0.10	<0.10	Nov 66	102	<20
	El Paso	29	5	<0.10	<0.10	<0.10	Aug 66	42	<9
Utah:	Salt Lake City	30	5	0.13	<0.10	<0.10	Sept 66	22	<4
Vt:	Barre	27	8	<0.10	<0.10	<0.10	Dec 66	83	<17
Va:	Richmond	30	7	<0.10	<0.10	<0.10	Dec 66	123	<25
Wash:	Seattle	30	4	<0.10	<0.10	<0.10	Dec 66	33	<7
	Spokane	30	2	<0.10	<0.10	<0.10	Nov 66	15	<3
W. Va:	Charleston	30	10	<0.10	<0.10	<0.10	June 66	76	<15
Wis:	Madison	29	3	<0.10	<0.10	<0.10	Dec 66	19	<4
Wyo:	Cheyenne	28	6	<0.10	<0.10	<0.10	Apr 66	36	<7
Network summary		1,889	360	0.35	<0.10	<0.10		82	<16

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.
[b] No precipitation sample collected.
[c] No report received.

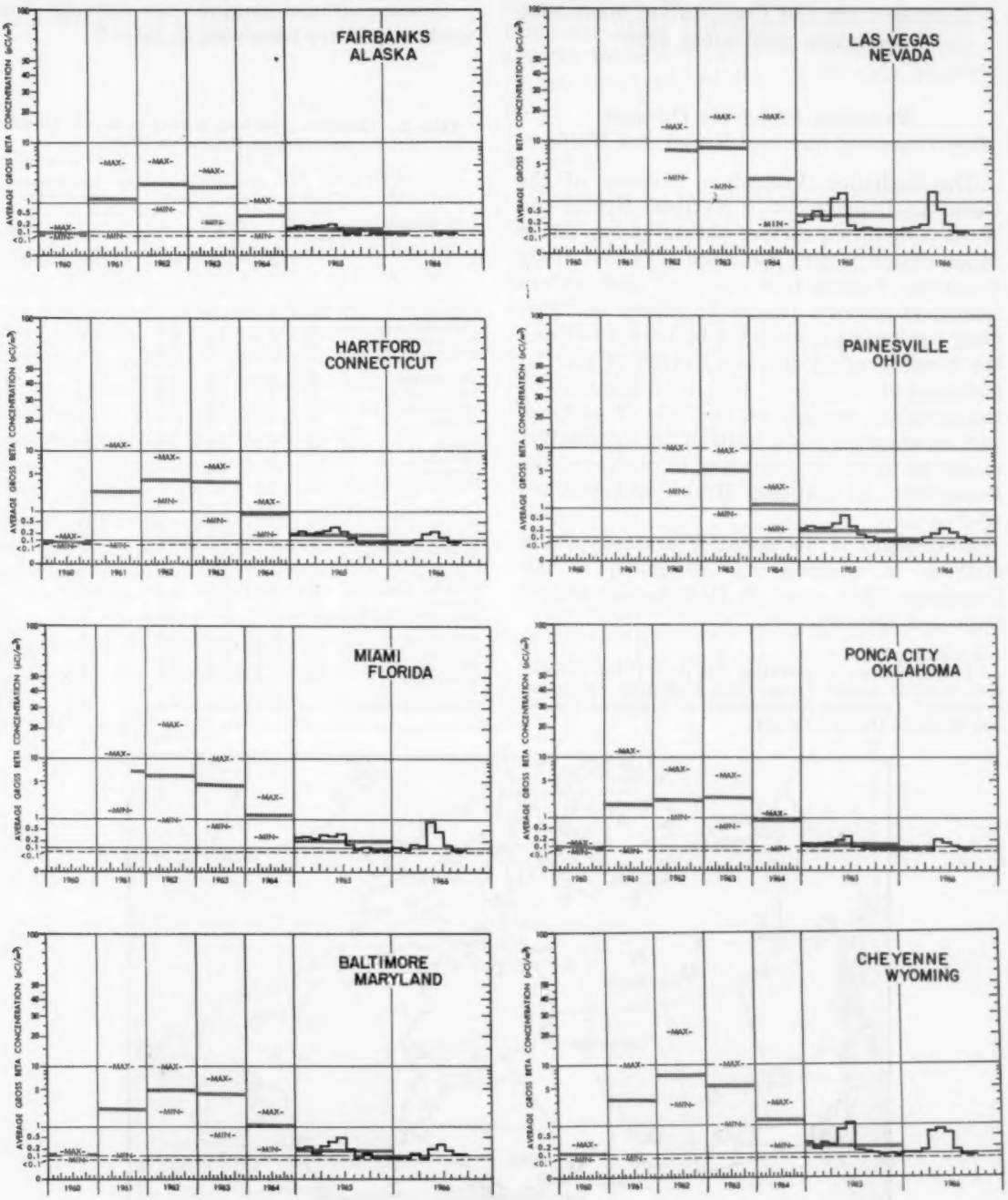

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960–September 1366

2. Canadian Air and Precipitation Monitoring Program, September 1966 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the October 1966 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for September 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, September 1966

Station	Number of samples	Air surveillance activity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition nCi/m²
Calgary	30	0.1	0.0	0.1	121	0.6
Coral Harbour	29	0.1	0.0	0.0	18	1.1
Edmonton	30	0.1	0.0	0.1	50	1.2
Ft. Churchill	30	0.1	0.0	0.0	31	1.3
Ft. William	29	0.1	0.0	0.1	9	0.3
Fredericton	20	0.1	0.0	0.0	10	1.0
Goose Bay	30	0.1	0.0	0.0	5	0.2
Halifax	29	0.1	0.0	0.1	10	0.9
Inuvik	30	0.1	0.0	0.0	15	0.6
Montreal	30	0.1	0.0	0.1	13	1.1
Moosonee	29	0.1	0.0	0.0	7	1.0
Ottawa	30	0.1	0.0	0.1	9	0.5
Quebec	21	0.1	0.0	0.0	10	1.6
Regina	30	0.1	0.0	0.1	48	0.6
Resolute	28	0.1	0.0	0.0	31	0.6
St. John's, Nfld.	30	0.1	0.0	0.0	11	0.7
Saskatoon	30	0.1	0.0	0.1	67	0.9
Sault Ste. Marie	30	0.1	0.0	0.1	17	1.3
Toronto	30	0.1	0.0	0.1	21	1.3
Vancouver	30	0.1	0.0	0.0	26	1.8
Whitehorse	30	0.1	0.0	0.0	10	0.4
Windsor	30	0.1	0.0	0.1	20	0.6
Winnipeg	30	0.2	0.0	0.1	57	1.0
Yellowknife	29	0.1	0.0	0.0	48	1.2
Network summary		0.1	0.0	0.1	28	0.9

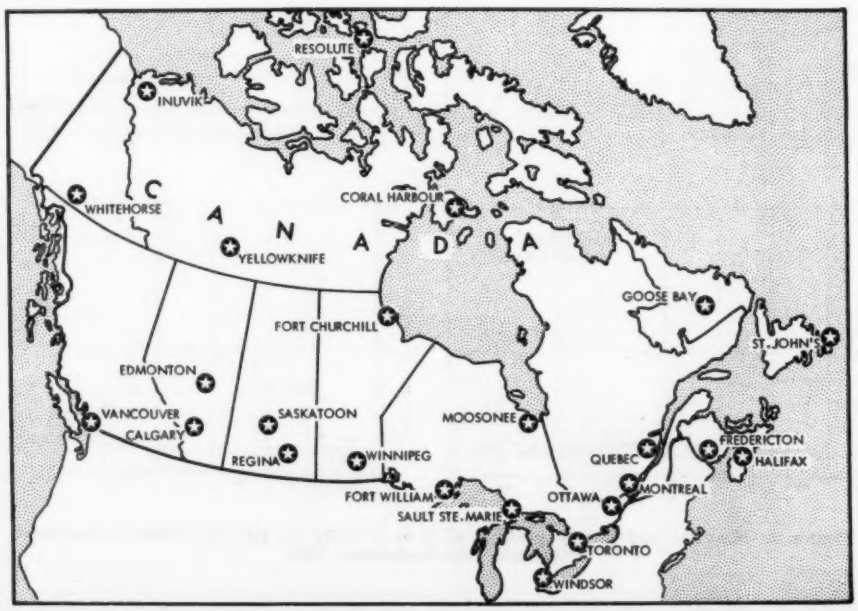

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program September 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day, using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta activity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month was needed to get a reliable average activity at each station (*8*).

The maximum, minimum, and average fission product beta concentrations in surface air during September 1966 are presented in table 3.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta activity of airborne particulates, September 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	9	<0.1	<0.1	<0.1
Chihuahua	7	<0.1	<0.1	<0.1
Ciudad Juárez	15	<0.1	<0.1	<0.1
Ensenada	2	0.1	0.1	0.1
Guadalajara	2	<0.1	<0.1	<0.1
Guaymas	5	0.1	<0.1	<0.1
La Paz	16	<0.1	<0.1	<0.1
Matamoros	11	<0.1	<0.1	<0.1
Mazatlán	9	0.1	<0.1	<0.1
Mérida	15	<0.1	<0.1	<0.1
México, D. F.	3	<0.1	<0.1	<0.1
Nuevo Laredo	NS	NS	NS	NS
San Luis Potosí	15	<0.1	<0.1	<0.1
Tampico	12	0.1	<0.1	<0.1
Torreón	13	<0.1	<0.1	<0.1
Veracruz	15	<0.1	<0.1	<0.1

NS, no sample collected: station temporarily shut down.

4. Pan American Air Sampling Program September 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for

Figure 5. Pan American Air Sampling Program stations

the Radiation Surveillance Network. The air-sampling station positions are shown in figure 5.

The September 1966 air-monitoring results from the participating countries are given in table 4. Levels were generally lower than

Table 4. PAHO gross beta activity in surface air September 1966

Station location	Number of samples	Gross beta activity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	22	10.97	<0.10	<0.49
Chile: Santiago	27	2.11	<0.10	<0.22
Columbia: Bogota	24	<0.10	<0.10	<0.10
Ecuador: Guayaquil	29	0.30	<0.10	<0.11
Jamaica: Kingston	23	<0.10	<0.10	<0.10
Peru: Lima	16	0.48	<0.10	<0.24
Venezuela: Caracas	1	<0.10	<0.10	<0.10
West Indies: Trinidad	21	0.11	<0.10	<0.10
Pan American summary	163	10.97	<0.10	<0.18

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more of the samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

August levels until the last 3 days of the month, when an abrupt rise in activity occurred in samples from Buenos Aires, Argentina, and Santiago, Chile. Concentrations of fresh fission products are identified in the samples in table 5. The decay index of the September 30, 1966, Buenos Aires sample indicates that the majority of the activity was probably from the French nuclear test on September 24, 1966. The other samples were not active enough for reliable "age" estimates.

Table 5. Fresh fission products in PAHO air samples September 1966

Location	Date	Concentration (pCi/m³)
Chile: Santiago	September 28	0.40
	September 29	2.11
Argentina: Buenos Aires	September 29	0.87
	September 30	10.97

5. National Air Sampling Network July–September 1966

National Center for Air Pollution Control
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. The resulting data aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors.

Gross beta activity in air

NASN stations (figure 6) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 non-urban areas. In addition, there are stations in 130 cities which operate every other year. Thus, the NASN consists of 240 sampling stations, 175 of which are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass-fiber filters on a biweekly random sampling schedule. They are sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. July through September 1966 gross beta activities in air are given in table 6.

Table 6. NASN fission product gross beta activity in surface air, July–September 1966

Station		Number of samples	Concentration, pCi/m³		
			Maximum	Minimum	Average
Ala:	Birmingham	6	0.2	0.1	0.1
	Gadsden	7	0.2	<0.1	0.1
	Mobile	7	0.2	<0.1	0.1
Alaska:	Anchorage	5	0.2	<0.1	0.1
Ariz:	Grand Canyon Park *	7	0.3	0.1	0.2
	Paradise Valley	7	0.3	0.1	0.1
	Phoenix	5	0.2	0.1	0.1
	Tucson	7	0.3	<0.1	0.1
Ark:	Little Rock	7	0.2	0.1	0.2
	Montgomery County *	6	0.2	0.1	0.1
	Texarkana	6	0.1	0.1	0.1
	West Memphis	7	0.2	0.1	0.1
Calif:	Burbank	7	0.2	0.1	0.1
	Humboldt County *	5	0.1	<0.1	0.1
	Los Angeles	7	0.2	0.1	0.1
	Oakland	5	0.1	0.1	0.1
	Pasadena	6	0.2	0.1	0.1
	San Diego	7	0.2	<0.1	0.1
	San Francisco	7	0.1	<0.1	0.1
Colo:	Denver	7	0.3	0.1	0.1
	Montezuma County *	7	0.3	0.1	0.1
Conn:	Hartford	7	0.3	0.1	0.2
	New Haven	7	0.3	<0.1	0.2
Del:	Kent County *	7	0.4	0.1	0.2
	Newark	7	0.4	0.1	0.2
	Wilmington	7	0.2	<0.1	0.1
D.C:	Washington	5	0.3	0.1	0.2
Ga:	Atlanta	7	0.2	<0.1	0.1
Hawaii:	Honolulu	7	0.2	<0.1	0.1
Idaho:	Boise	7	0.4	0.1	0.2
	Butte County *	7	0.4	0.1	0.2
Ill:	Chicago	7	0.3	0.1	0.2
Ind:	East Chicago	7	0.3	0.1	0.2
	Hammond	7	0.3	0.1	0.2
	Indianapolis	7	0.4	0.1	0.2
	N. Monroe State Forest	6	0.3	<0.1	0.2
	Muncie	7	0.4	0.1	0.2
	New Albany	7	0.3	0.1	0.2
	Parke County *	7	0.6	0.1	0.2
	South Bend	6	0.3	0.1	0.1
	Terre Haute	6	0.3	0.1	0.2
Iowa:	Davenport	7	0.3	0.1	0.2
	Delaware County *	4	0.2	0.1	0.2
	Des Moines	7	0.2	0.1	0.1
	Dubuque	7	0.3	0.1	0.2
Kans:	Kansas City	7	0.2	0.1	0.1
	Wichita	6	0.2	0.1	0.1
Ky:	Ashland	7	0.3	0.1	0.2
	Covington	7	0.3	0.1	0.2
	Louisville	7	0.3	0.1	0.2
La:	New Orleans	7	0.2	0.1	0.1
Maine:	Acadia National Park *	7	0.3	0.1	0.1
	Portland	6	0.3	<0.1	0.1
Md:	Baltimore	7	0.3	0.1	0.2
	Calvert County *	6	0.2	0.1	0.1
Mich:	Detroit	7	0.3	0.1	0.2
Minn:	Duluth	7	0.3	0.1	0.1
	Minneapolis	7	0.3	0.1	0.2
	Moorhead	7	0.3	<0.1	0.1
	St. Paul	7	0.3	0.1	0.2
Miss:	Jackson	7	0.3	0.1	0.1
	Jackson County *	7	0.3	<0.1	0.1
Mo:	Kansas City	7	0.2	0.1	0.2
	St. Louis	7	0.4	0.1	0.2
	Shannon County *	6	0.3	0.1	0.2
Mont:	Glacier National Park *	6	0.2	0.1	0.1
	Helena	7	0.4	0.1	0.2
Nebr:	Omaha	7	0.3	0.1	0.2
	Thomas County *	7	0.3	0.1	0.2
Nev:	Las Vegas	7	0.4	0.1	0.2
	White Pine County *	7	0.2	0.1	0.1
N.H:	Concord	7	0.3	0.1	0.2
	Coos County *	7	0.2	0.1	0.2
N.J:	Marlton	7	0.3	0.1	0.2
	Camden	7	0.3	0.1	0.2
	Glassboro	7	0.3	0.1	0.2
	Jersey City	6	0.2	0.1	0.2
	Newark	7	0.3	<0.1	0.1
	Perth Amboy	7	0.4	0.1	0.2
	Trenton	5	0.2	0.1	0.1
N. Mex:	Albuquerque	7	0.3	0.1	0.1
	Rio Arriba County *	5	0.1	0.1	0.1
N.Y:	Cape Vincent *	7	0.2	0.1	0.1
	New York	7	0.3	0.1	0.2
N.C:	Charlotte	7	0.4	0.1	0.2
	Cape Hatteras *	7	0.3	<0.1	0.1
Ohio:	Akron	6	0.4	0.1	0.2
	Cincinnati	7	0.3	0.1	0.2
	Cleveland	7	0.3	0.1	0.2
	Columbus	7	0.3	0.1	0.2
	Dayton	7	0.3	0.1	0.2
	Toledo	7	0.4	0.1	0.2
	Youngstown	7	0.3	0.1	0.2
Okla:	Cherokee County *	7	0.3	0.1	0.2
	Oklahoma City	7	0.3	0.1	0.2
	Tulsa	7	0.3	0.1	0.1
Ore:	Curry County *	7	0.1	<0.1	<0.1
	Portland	5	0.1	0.1	0.1
Pa:	Clarion County *	7	0.3	0.1	0.1
	Lancaster	7	0.4	0.1	0.2
	Philadelphia	6	0.3	<0.1	0.2
	Pittsburgh	7	0.2	0.1	0.1
	Reading	7	0.2	<0.1	0.1
	Warminster	7	0.3	0.1	0.2
	West Chester	3	0.2	0.1	0.2
P.R:	Bayamón	7	0.1	0.1	0.1
	Guayanilla	7	0.2	<0.1	0.1
	Ponce	7	0.1	<0.1	0.1
	San Juan	6	0.2	<0.1	0.1
R.I:	Providence	7	0.3	0.1	0.2
	Washington County *	6	0.3	0.1	0.2
S.C:	Columbia	6	0.5	0.1	0.2
	Greenville	7	0.3	0.1	0.2
	Richland County *	7	0.3	<0.1	0.1
S. Dak:	Black Hills Forest *	7	0.3	0.1	0.2
	Sioux Falls	7	0.3	0.1	0.2
Tenn:	Chattanooga	6	0.3	<0.1	0.1
	Memphis	7	0.2	0.1	0.1
	Nashville	7	0.2	0.1	0.1
Tex:	Dallas	6	0.3	0.1	0.1
	Houston	6	0.2	<0.1	0.1
	Matagorda County *	6	0.2	<0.1	0.1
	Pasadena	4	0.2	<0.1	0.1
	San Antonio	7	0.2	<0.1	0.1
Utah:	Ogden	6	0.2	0.1	0.1
	Salt Lake City	7	0.3	0.1	0.2
Vt:	Burlington	7	0.3	0.1	0.2
	Orange County *	7	0.3	0.1	0.2
Va:	Danville	5	0.4	0.1	0.2
	Norfolk	7	0.3	0.1	0.1
	Shenandoah Nat'l Park *	7	0.4	<0.1	0.1
Wash:	Seattle	7	0.1	<0.1	0.1
W. Va:	Charleston	6	0.3	0.1	0.2
Wis:	Door County *	4	0.2	<0.1	0.1
	Milwaukee	7	0.3	0.1	0.2
Wyo:	Cheyenne	7	0.2	0.1	0.1
	Yellowstone Nat'l Park *	7	0.4	0.1	0.2

* Non-urban station.

Figure 6. National Air Sampling Network locations, 1966

6. Surface Air Sampling Program— 80th Meridian Network January–December 1965 [2]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objectives of this program are to determine the concentrations of radioactivity in surface air in both hemispheres as a function of latitude and season, and to interpret these data in terms of the dominant meteorological and physical processes which are operative.

The basic network consists of a line of sites approximately along the 80th meridian extending from about 76°N to 53°S latitudes (figure 7). Duplicate collections are made at the New York site which provide a measure of the reproducibility of sampling and analysis in this program. Additional sites in Hawaii and in the continental United States were implemented to supply data relating to possible longitudinal, coastal, or altitude effects of surface air concentrations. The Environmental Science Services Administration maintains a collection site at the Amundson Scott Station in Antarctica. The air-filter samples from this site are also included in the HASL Program.

Sampling and analytical procedures

Approximately 1,400 cubic meters of ambient air per day are drawn through an 8-inch-diameter Microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air. Under normal conditions, the filters from each station are compressed into a monthly composite and

[2] Summarized from "Fallout Program Quarterly Summary Report," HASL–173, available from the Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151.

Figure 7. 80th Meridian Network sampling stations

the gamma-ray spectrum of the composite is obtained by an 8- by 4-inch NaI (Thallium) crystal approximately 2 weeks after the last collection in the month. If a nuclear event occurs and measurable quantities of radioactivity are injected into the atmosphere, each filter collected in the same hemisphere in which the event takes place is assayed individually in an attempt to better delineate the disposition and dispersion of the nuclear debris during the ensuing weeks.

The integrated response between 100 KeV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma-ray photons present in fallout and the total gamma-ray activity is reported in units of photons/min • 1,000 m^3. Average monthly gamma-ray concentrations are calculated by weighting the concentrations in each sampling interval by the relative period of time in the interval. After the gamma-ray measurements have been completed monthly composites from each site are submitted to contractor laboratories for radiochemical analyses.

Since the last major nuclear weapon test series occurred at the end of 1962, only the longer-lived artificially produced radionuclides were present in the filters analyzed. Consequently, emphasis was given to the determination of manganese–54, iron–55, strontium–90, cadmium–109, cesium–137, cerium–144, and at some sites, plutonium–238 and plutonium–239. Strontium–89 and zirconium–95 were analyzed in samples collected in May and June after the second Chinese nuclear test of May 14, 1965.

The longer-lived fission products and plutonium–239 concentrations should describe the general distribution in surface air of all previous nuclear weapons debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer radionuclides can be associated with debris from a single detonation or a series of detonations. Manganese–54 and iron–55 were produced in large quantities in the 1961 and 1962 test series. Cadmium–109 was generated by the U.S. high-altitude test over Johnston Island on July 9, 1962. While plutonium–238 is present in low concentrations in nuclear weapons debris, about 17,000 curies of plutonium–238 were disseminated at high altitude in the stratosphere on April 21, 1964, during the re-entry burnup of a SNAP–9A power source.

During 1965, Food, Chemical and Research Laboratories, Inc., (FCRL) of Seattle, Wash., performed the analyses of most of the samples in this program. Isotopes, Inc., of Westwood, N.J., analyzed most of the samples collected at Westwood; Lima, Peru; and Chacataya, Bolivia. Hazelton-Nuclear Science Corporation of Palo Alto, California, analyzed practically all of the samples from Sterling, Virginia, and Antofagasta, Chile. Previous reports containing data on the HASL Surface Air Sampling Program are given in references (*9–12*).

Results

The updated activity concentrations in surface air during 1965 are presented in tables 7 through 17. The sites are listed according to latitude beginning with the most northern site at Thule, Greenland. The coded duplicate samples from the New York site were analyzed, and these results are also given in tables 7 through 17. Such duplicate samples were part of a quality control program maintained with Food, Chemical and Research Laboratories, Inc., in which coded duplicates, standards, and blanks were submitted with each shipment of samples. The results of the standards and blank analyses are reported in table 18.

The concentrations are reported at the midpoint of the collection month for the plutonium isotopes and the fission products and on the following dates for the induced radionuclides:

Manganese–54 and iron–55:

October 15, 1961

Cadium–109:

July 9, 1962.

One standard deviation of the counting error for these data is always less than ±20 percent and usually less than 10 percent unless otherwise indicated. Data are suspect when the concentration of a radionuclide is inconsistent with:

1. Its concentrations in samples adjacent in time and place
2. Concentrations of other radionuclides in the same sample.

Some of the plutonium–238 and –239 concentrations during October 1965 which were reported earlier (*12*) have been omitted in tables 16 and 17 because of analytical errors which have been uncovered but cannot be resolved.

Data reliability

According to Volk (*13*) an estimate of the standard deviation of an analysis can be obtained from duplicate measurements by the equation:

$$\sigma = 0.8862\ \bar{d}$$

where σ = percent standard deviation

$\bar{d}$ = deviation between duplicate measurements expressed as percent of the mean.

Invoking this equation, the standard deviation for each duplicate measurement at New York is reported in tables 7 through 17 along with the average standard deviation for each radionuclide during the time interval covered by this report. Deviations are given only for duplicates where the counting error is less than ± 20 percent. The average percent standard deviation for all radionuclides except strontium–89 is 16 percent or better. The listed average percent standard deviation for strontium–89 is 45 percent. While the strontium–89 analysis is probably less reliable than the other radionuclide analyses, not enough duplicate strontium–89 measurements were performed to permit an adequate evaluation of that reliability.

A blank is prepared by sprinkling a small amount of pre-1945 soil (<100 mg) onto an unexposed Microsorban filter. Then carbon soot from burning naphthalene is filtered onto the Microsorban paper for a few moments under laboratory conditions. This procedure produces blanks which are very similar in appearance and, in some respects, composition to the routine filters collected by this program. When the blanks are coded, as are all the filters submitted for radiochemistry, they are not readily distinguishable from routine samples.

A standard is prepared by evaporating weighed aliquots of standard solutions of various radionuclides calibrated at HASL onto a blank sample which was prepared by the procedure just described. However, since Microsorban is a polyethylene-base paper, it is not wetted by aqueous solutions. To avoid this problem, the tracer solutions were added to one of two pieces of backing paper which accompany each sample. The backing paper readily absorbs the tracer solutions, and is completely dissolved with the Microsorban filter prior to radiochemical analysis. The results of the coded blank and standard sample analyses are given in table 18.

Table 7. Gamma activity in surface air, January–December 1965

(gamma ray activity, photons/min•1,000 m³)

Station	Latitude	Longitude	Elevation (feet)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere															
Thule, Greenland	76° 36′	68° 35′	259	184	132	287	242	206	143	112	72.3	52.2	41.0	30.5	43.2
Moosonee, Canada	51° 16′	80° 39′	10	98.3	132	183	206	236	379	167	45.3	30.2	24.0	14.7	21.3
Seattle, Wash	47° 36′	122° 20′	3	68.4	147	342	138	138	244	77.9	47.0	50.6	30.3	25.9	27.4
Appleton, Wis	44° 15′	88° 25′	229	133	188	295	235	283	716	261	74.8	34.0	31.8	26.6	25.8
Westwood, N.J	41° 00′	74° 01′	38	143	202	202	234	508	537	324	78.9	52.0	35.4	—	—
New York, N.Y	40° 48′	73° 58′	38	163	223	234 220 227 ±3.1	259 264 261 ±1.8	545	829	322	81.1	67.6	50.2	38.7	34.1
Sterling, Va	38° 58′	77° 25′	76	140	209	177	217	419	647	218	[b]89.3	47.8	[b]31.7	38.2	31.1
Palo Alto, Calif	37° 30′	122° 23′	19	95.4	227	311	166	208	264	71.6	52.1	70.1	35.2	41.0	29.9
Midwest City, Okla	35° 25′	97° 30′	364	155	195	245	325	467	951	160	84.5	50.1	—	—	—
Norman, Okla	35° 14′	97° 27′	364	—	—	—	—	—	—	—	—	—	21.9	35.2	41.3
Chattanooga, Tenn	35° 03′	85° 20′	206	163	198	204	266	332	728	180	84.2	59.1	48.9	43.5	37.1
Miami, Fla	25° 49′	80° 17′	4	165	198	224	346	407	452	106	49.4	40.7	37.0	40.9	41.6
Mauna Loa, Hawaii	19° 28′	155° 36′	3,401	128	310	209	144	647	393	103	55.3	33.4	35.5	20.4	30.1
San Juan, P.R	18° 26′	66° 00′	10	111	133	186	222	123	627	101	47.3	22.5	17.4	14.0	15.8
Miraflores, C.Z	9° 00′	79° 35′	10	74.8	84.4	[a]29.0	125	99.3	—	—	—	—	—	—	—
Balboa, C. Z	8° 58′	79° 34′	23	—	—	—	—	—	109	56.4	17.9	8.39	5.26	5.63	17.2
Southern Hemisphere															
Guayaquil, Ecuador	2° 10′	79° 52′	7	30.1	23.6	16.1	27.0	12.2	15.3	12.5	14.0	10.3	12.0	14.3	10.6
Lima, Peru	12° 03′	77° 01′	134	65.0	52.3	102	[b]37.3	33.3	35.3	[b]28.4	41.4	37.9	[b]38.0	34.9	28.8
Chacaltaya, Bolivia	21° 21′	68° 07′	5,220	16.5	17.1	25.8	16.0	31.0	35.6	24.4	19.9	30.4	21.3	14.2	—
Antofagasta, Chile	23° 37′	70° 16′	519	60.4	54.9	48.4	41.3	35.9	34.2	40.7	43.9	54.3	25.5	31.7	—
Santiago, Chile	33° 27′	70° 42′	520	76.6	62.4	51.4	47.0	53.0	39.4	37.1	44.2	49.8	25.5	—	28.4
Puerto Montt, Chile	41° 27′	72° 57′	5	43.3	49.5	39.5	34.0	23.0	16.4	16.8	16.1	14.6	16.2	13.6	14.2
Punta Arenas, Chile	53° 08′	70° 53′	3	26.8	37.1	30.4	27.0	19.7	12.3	11.1	8.76	18.6	8.09	8.89	11.1

[a] Data suspect.
[b] Analysis performed by FCRL.

In the January and February sample shipment, the blank samples were separate and distinct from the standard samples. Thereafter, any particular quality-control sample might be a blank for certain radionuclides and a standard for others depending upon whether tracer solution was added or not. A review of the blank data in table 11 indicates that the laboratory contamination for most of the nuclides studied is either not measurable or at a level which is usually negligible with regard to the activity levels in the samples. A notable exception is manganese–54 because its contamination level approaches the activities measured in the filter samples collected at the low and high latitude stations of the Southern Hemisphere (Guayaquil and Punta Arenas) from about mid-1965.

FCRL has performed some plutonium–238 and plutonium–239–240 analyses on surface air filter samples beginning in June 1965. The previous plutonium analyses performed in this program were conducted by Hazleton Nuclear Science Corporation and Isotopes, Inc. The blank analyses which were performed by FCRL and are reported in table 18 indicate that since July 1965 the laboratory contamination for plutonium–238 at FCRL is, at times, equivalent to the activity levels measured in the samples. This in effect invalidates practically all of FCRL's plutonium–238 measurements. It should be stressed that plutonium–238 measurements of surface air filter samples are very difficult analyses which are compounded by the extremely minute quantity of plutonium–238 which is present.

The previous evaluation of the data in table 11 from January through June 1965 (*11*) suggested that there may have been serious errors at times in the preparation or processing of the standard samples or that the standards and their analyses are not wholly representative of the routine surface air samples. It was proposed that future standards would be prepared by dispersing the tracer solutions directly on the Microsorban filter with a wetting agent instead of on the backing paper so that the standard would more closely resemble the routine samples. Unfortunately, this modification was not put into effect until the November 1965 samples were submitted for analyses. However, extra care was taken in the preparation of the July through October standards.

The overall accuracy of FCRL's analyses of samples which were collected in 1965 is reflected in the average percent deviation reported in table 18. There appears to be a negative bias for all radionuclides, most of them being accurate to within 15 percent. Cadmium–109 and plutonium–239 results are more extreme, being consistently low by an average of about 25 and 50 percent, respectively.

This behavior of the cadmium–109 and plutonium–239 data suggests that a sizable error exists in the calibration of the radioassay equipment for these two nuclides. However, the variability of the bias for these two nuclides argues that a more serious non-systematic error may also be involved such as impure separations, incorrect radiochemical yields, or unstable radioassay equipment. All cadmium fractions from samples collected during 1965 are being reassayed at HASL in an effort to resolve the uncertainties of analysis and in order to report lower levels of detection. Plutonium analyses have been suspended until the reliability of analysis which was demonstrated in early 1965 can be reestablished. The bulk of the plutonium analyses for 1965 which were reported by Isotopes, Inc., and Hazleton Nuclear Science Corporation appear to be internally reasonable and consistent.

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Table 8. Manganese-54 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000 m³ of composite monthly samples decay corrected to October 15, 1961)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	302	238	445	373	255	120	91.7	98.9	90.3	80.1	151	93.2
Moosonee	156	215	274	313	[a] 320	227	129	99.3	50.7	49.8	37.8	43.9
Seattle	382	170	382	232	229	196	73.2	—	—	—	—	—
Appleton	195	317	293	309	307	349	212	155	73.2	63.5	[b] 36.0	60.5
Westwood	—	228	175	302	275	271	—	—	—	—	—	—
New York	218	330	290	355	327	354	236	159	102	85.7	76.6	71.2
	204	324	288	342	303	417	265	164	98.1	82.5	55.0	[a] 62
	211	327	289	349	315	386	251	162	100	84.1	65.9	66.8
	±5.8	±1.6	±0.1	±3.3	±6.1	±14	±10	±2.7	±3.5	±3.4	±29	±12
Sterling	222	356	296	285	448	[a] 445	180	[c] 124	[a] 102	[c] 60.0	67.4	61.2
Palo Alto	147	381	462	233	277	171	119	94.6	112	77.6	70.0	69.7
Midwest City	231	315	349	468	375	300	176	107	81.7	—	—	—
Norman	—	—	—	—	—	—	—	—	—	110	85.3	ND
Chattanooga	194	272	238	280	333	212	166	111	71.7	79.5	[b] 50.5	79.2
Miami	263	332	334	516	572	223	87.4	63.5	52.5	75.3	87.0	100
Mauna Loa	199	536	346	209	183	189	129	73.4	45.1	60.0	36.2	60.4
San Juan	176	210	177	332	154	176	98.4	56.5	[a] 41	27.7	[a] 20	37.1
Miraflores	114	131	173	160	78.2	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	26.9	[b] 22.6	[a] 14	ND	[d] 6.8	[a] 9.3	32.8
Southern Hemisphere												
Guayaquil	30.4	32.5	ND	[d] 9.4	[d] 7.7	[d] 5.2	[a] 17	[a] 8.5	[d] 6.4	21.1	[a] 18	[a] 24
Lima	—	45.0	44.4	43.5	[b] 292	25.5	[c] 34.8	—	—	[b] 81.7	—	60.4
Chacaltaya	—	16.4	20.0	[b c] 269	[b] 538	26.0	—	—	—	40.5	—	—
Antofagasta	98.5	72.4	60.2	54.7	[a] 49	51.0	52.7	63.7	95.4	41.2	—	—
Santiago	87.5	67.9	54.3	31.5	26.9	[a] 19	39.8	42.0	50.0	54.2	—	—
Puerto Montt	63.3	72.0	49.6	46.9	35.0	19.9	[d] 35	13.2	[a] 18	[a] 21.8	[a] 18	[a] 25
Punta Arenas	31.3	50.2	38.0	32.8	29.3	[a] 9.7	[a] 16	[a] 7.7	[a] 31	[a] 15	[d] 9.0	[a] 12

[a] Counting error is 20–50 percent.
[b] Data suspect.
[c] Analysis performed by FCRL.
[d] Counting error is 51–100 percent.
ND, not detectable.

Table 9. Iron-55 concentrations in surface air, January–December, 1965

(concentrations, dpm/1,000 m³ of composite monthly samples decay corrected to October 15, 1961)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	352	330	521	560	235	124	124	120	108	74.1	142	99.3
Moosonee	199	279	431	394	434	291	148	126	60	56.2	53.4	43.7
Seattle	626	265	629	315	302	299	118	110	96.2	[a] 9.42	[a] 1.73	63.0
Appleton	292	424	383	406	406	474	282	213	62.9	111	70.1	89.6
Westwood	264	257	215	365	588	380	242	176	83.6	68.8	—	—
New York	338	534	435	327	582	479	292	182	153	140	105	97.7
	325	557	122	406	527	536	337	214	125	95.7	103	55.6
	332	546	435	367	554	508	315	198	139	118	104	76.6
	±3.4	±3.7		±19	±8.8	±9.7	±13	±14	±18	±33	±1.7	±49
Sterling	—	[a] 202	165	438	457	235	265	134	69.6	79.6	98.0	77.5
Palo Alto	208	488	668	275	271	201	194	100	90.4	117	60.8	70.8
Midwest City	324	397	484	516	536	386	206	139	85.1	—	—	—
Norman	—	—	—	—	—	—	—	—	—	138	93.6	106
Chattanooga	353	—	381	550	602	288	263	151	78.2	161	105	132
Miami	340	490	400	578	631	268	121	68.0	67.9	65.7	81.8	134
Mauna Loa	237	765	376	200	239	244	156	92	56.8	84.2	53.8	77.2
San Juan	242	291	280	438	185	197	128	67.5	41.3	38.8	41.5	33.2
Miraflores	155	198	227	221	110	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	[a] 72	56.4	[b] 24	[b] 9.9	[b] 8.5	[a] 41.6	29.6
Southern Hemisphere												
Guayaquil	45.3	31.1	25.9	[c] 8.7	ND	ND	[b] 22	[c] 11	ND	[a b] 7.4	[a] 50.5	[b] 26
Lima	103	49.6	55.3	[b d] 38	24.6	32.6	[a d] 70.5	45.9	65.6	[b] 112	—	63.1
Chacaltaya	27.1	19.2	25.3	10.8	15.6	27.9	[b] 22.7	27.7	43.8	48.5	—	—
Antofagasta	52.8	—	76.9	62.6	43.7	48.8	61.0	66.8	152	54.0	—	—
Santiago	158	96	[a] 53	[b] 41	[b] 76	ND	[a] 111	[b] 54	[b] 34	[b] 83	—	80.9
Puerto Montt	97.5	97.2	70.8	47.5	36.1	36.6	[b] 15	15.0	28.5	37.2	25.3	26.4
Punta Arenas	60.5	77.5	45.9	40.7	18.0	[b] 21	24.2	[b] 13	[c] 18	[b] 34	[b] 31	[a b] 53

[a] Data suspect.
[b] Analysis performed by FCRL.
[c] Counting error is 20–50 percent.
[d] Counting error is 51–100 percent.
ND, not detectable.

Table 10. Strontium-89 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule					ND	[a] 10.3	9.73					
Moosonee					ND	39.0	56.3					
Seattle					ND	ND	19.8					
Appleton					ND	113	37.2					
Westwood					ND	46.8	—					
New York						82.5	40.9					
						99.3	98.0					
					[b] 13.6	90.9	69.5					
						±18	±78					
Sterling					19.5	93.2	47.4					
Palo Alto					ND	37.7	30.4					
Midwest City					21.8	107	53.2					
Norman					—	—	—					
Chattanooga					44.0	83.0	ND					
Miami					[d] 2.6	58.3	14.6					
Mauna Loa					67.3	56.0	ND					
San Juan					5.6	74.0	[a] 18					
Miraflores					[a] 2.0	—	—					
Balboa					—	14.5	11.6					
Southern Hemisphere												
Guayaquil					ND	ND	5.2					
Lima					ND	ND	[a] 8.2					
Chacaltaya					ND	0.8	—					
Antofagasta					[a] 2.9	1.2	ND					
Santiago					ND	ND	[a] 11					
Puerto Montt					ND	ND	ND					
Punta Arenas					ND	ND	ND					

[a] Counting error is 20–50 percent.
[b] Monthly strontium-89 concentration calculated from analyses of several highly radioactive daily samples.
[c] Analysis performed by FCRL.
[d] Counting error is 50–100 percent.
ND, not detectable.

Table 11. Strontium-90 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	36.6	24.1	52.3	42.9	31.5	13.7	9.73	14.6	11.5	9.23	17.7	11.2
Moosonee	18.8	24.9	28.5	31.7	33.5	28.6	11.6	13.3	5.69	5.56	4.89	5.2
Seattle	52.5	22.3	52.5	26.1	24.9	29.4	10.8	11.3	7.8	7.35	6.54	5.63
Appleton	24.3	35.2	34.2	34.5	40.5	44.1	26	19.7	8.85	9.96	6.35	7.1
Westwood	25.9	33.3	37.3	44.2	42.6	29.6	33.5	[a] 34.7	11.6	11.8	—	—
New York	26.3	33.1	35.8	45.2	39.6	46.0	26.3	23.5	15.7	11.1	10.5	8.6
	26.7	39.0	32.9	38.5	43.0	56.2	22.3	22.3	14.5	10.1	8.57	7.5
	26.5	36.0	34.4	41.9	41.3	51.1	24.3	22.9	15.1	10.6	9.54	8.05
	±1.3	±14	±7.4	±14	±7.2	±18	±15	±4.6	±7	±8.4	±18	±12
Sterling	26.9	36.7	31.3	39.8	38.8	28.4	[a] 33.4	[b] 19.2	10.1	[b] 8.63	9.2	8.7
Palo Alto	18.8	39.9	59.1	29.6	28.8	19.9	13.8	11.6	15.9	9.28	9.23	6.7
Midwest City	28.7	33.6	40.5	56.8	43.3	42.2	18.2	16.3	10.6	—	—	—
Norman	—	—	—	—	—	—	—	—	—	13.7	10.7	13.3
Chattanooga	29.4	34.2	34.6	43.7	44.4	32.8	19.1	15.0	11.7	11.8	9.89	9.6
Miami	31.8	35.2	35.5	52.5	55.0	25.6	10.4	8.23	6.22	8.72	9.67	10.1
Mauna Loa	25.2	50.6	34.0	28.1	20.4	22.8	17.2	9.74	5.73	7.84	5.17	8.6
San Juan	21.5	25.0	23.6	41.4	14.7	21.9	12.8	7.72	3.4	3.52	3.12	4.1
Miraflores	13.8	14.4	19.3	23.2	9.22	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	4.32	5.2	2.93	0.92	0.95	0.94	3.3
Southern Hemisphere												
Guayaquil	5.54	3.31	2.17	[c] 0.91	0.90	1.22	1.38	1.46	1.59	2.4	3.10	2.4
Lima	[a] 5.21	8.34	9.46	[b] 4.69	4.32	4.30	[b] 4.63	7.08	9.98	[b] 10.5	8.18	5.4
Chacaltaya	[a] 7.9	2.21	3.29	1.53	2.17	2.88	[d] 2.39	3.44	5.88	4.64	3.15	—
Antofagasta	12.7	11.5	8.73	7.19	3.67	4.94	9.30	9.07	13.2	1.34	8.64	—
Santiago	17.4	12.7	9.72	6.05	5.85	3.64	6.92	6.28	8.9	6.43	—	5.2
Puerto Montt	11.4	10.6	8.31	4.9	4.26	3.21	2.67	2.8	3.47	3.5	2.62	5.2
Punta Arenas	6.00	7.95	6.23	5.10	3.50	2.21	2.19	1.61	4.32	1.97	1.57	2.4

[a] Data suspect.
[b] Analysis performed by FCRL.
[c] Counting error is 20–50 percent.
[d] Counting error is 51–100 percent.

Table 12. Zirconium-95 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	1.21	[a] 0.59	—	—	17.5	22.6	13.5	—	—	—	—	—
Moosonee	1.27	[a] 0.86	—	—	15.1	51.0	15.0	—	—	—	—	—
Seattle	1.13	[a] 0.44	1.13	—	1.09	44.1	5.45	—	—	—	—	—
Appleton	1.28	[a] 0.55	—	—	11.4	91.7	21.1	—	—	—	—	—
Westwood	ND	ND	—	—	3.0	92.3	—	—	—	—	—	—
New York	0.68	[a] 0.40	—	—	11.1	95.6	20.1	—	—	—	—	—
	0.90	[a] 0.50	—	—	11.3	100	23.1	—	—	—	—	—
	0.79	0.45			11.2	97.8	21.6					
	±25	±19	—	—	±1.9	±4	±12	—	—	—	—	—
Sterling	ND	[b] 26.4	—	—	6.32	71.3	17.5	—	0.576	—	—	—
Palo Alto	0.77	0.99	—	—	13.6	41.7	5.54	—	—	—	—	—
Midwest City	0.75	1.09	—	—	29.5	97.2	7.46	—	—	—	—	—
Norman	—	—	—	—	—	—	—	—	—	—	—	—
Chattanooga	0.99	[a] 0.69	—	—	6.15	75.0	7.2	—	—	—	—	—
Miami	0.97	1.21	—	—	13.5	43.6	5.0	—	—	—	—	—
Mauna Loa	0.73	1.40	—	—	55.6	28.7	[c] 1.3	[a] 0.33	—	—	—	—
San Juan	[a] 0.64	ND	—	—	3.70	72.3	14.4	—	—	—	—	—
Miraflores	[a] 0.53	[a] 0.41	—	—	4.58	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	8.04	4.2	—	—	—	—	—
Southern Hemisphere												
Guayaquil	[c] 0.15	—	—	—	[a] 0.37	1.72	ND	—	—	—	—	—
Lima	ND	—	—	—	ND	0.809	[d] ND	—	—	—	—	—
Chacaltaya	ND	—	—	—	—	0.577	—	—	—	—	—	—
Antofagasta	[b] 5.8	ND	—	—	0.678	0.499	ND	—	—	—	—	—
Santiago	[c] 0.16	—	—	—	[c] 0.17	ND	ND	—	—	—	—	—
Puerto Montt	[c] 0.21	—	—	—	ND	ND	ND	—	—	—	—	—
Punta Arenas	ND	—	—	—	ND	ND	ND	—	—	—	—	—

[a] Counting error is 20–50 percent.
[b] Data suspect.
[c] Counting error is 51–100 percent.
[d] Analysis performed by FCRL.
ND, not detectable.

Table 13. Cadmium-109 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000 m³ of composites monthly samples decay corrected to July 9, 1962)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	ND	[a] 0.17	ND	ND	[a] 0.52	ND	ND	[b] 0.38	[a] 0.20	[a] 0.13	[b] 0.31	ND
Moosonee	ND	ND	ND	ND	[a] 0.64	ND	[a] 0.53	[a] 1.7	[a] 0.10	ND	[a] 0.11	[a] 0.23
Seattle	ND	ND	ND	ND	[b] 0.50	ND	ND	ND	[b] 0.30	ND	ND	[b] 0.34
Appleton	ND	ND	ND	ND	[b] 0.82	[b] 0.44	ND	ND	[b] 0.18	[a] 0.92	[a] 0.82	ND
Westwood	ND	ND	ND	0.227	ND	[b] 0.31	[a] 0.32	0.245	[a] 3.38	[b] 0.23	—	—
New York	ND	[a] 0.38	ND	ND	[b] 2.22	ND	ND	[b] 0.29	[b] 0.30	ND	[a] 0.33	ND
	ND	ND	ND	ND	[a] 1.3	[a] 0.47	ND	ND	[a] 0.12	ND	ND	[a] 0.19
					[a] 1.8				[a] 0.21			
Sterling	0.235	ND	[b] 0.15	[b] 0.14	0.17	0.323	0.920	[a,d] 1.8	0.576	[d] ND	[b] 0.022	[b] 0.38
Palo Alto	ND	ND	[a] 0.16	[a] 0.34	ND	ND	ND	[b] 0.51	ND	ND	[b] 0.37	ND
Midwest City	[b] 0.09	ND	ND	ND	ND	[b] 0.68	[a] 0.65	[a] 1.8	[a] 0.16	—	—	—
Norman	—	—	—	—	—	—	—	—	—	—	[b] 0.38	[b] 0.22
Chattanooga	ND	ND	ND	[a] 0.40	[a] 1.00	[a] 0.55	ND	[a] 0.31	[a] 0.11	ND	ND	[a] 0.19
Miami	ND	[a] 0.24	ND	[a] 0.22	[b] 1.16	ND	ND	[a] 0.26	[a] 0.19	ND	[b] 0.36	[a] 0.16
Mauna Loa	ND	ND	[b] 0.58	[a] 0.22	ND	ND	ND	—	[b] 0.18	ND	ND	[b] 0.20
San Juan	ND	ND	ND	ND	[b,c] 0.83	[a] 0.27	[a] 0.24	[a] 0.11	ND	ND	ND	[a] 0.18
Miraflores	ND	ND	ND	ND	ND	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	[a] 0.63	ND	[a] 0.28	ND	ND	[a] 0.41	ND
Southern Hemisphere												
Guayaquil	ND	[a] 0.22	ND	ND	[a,c] 0.58	[b,c] 1.28	ND	ND	[b] 0.24	[a] 0.17	[a] 0.35	[b] 0.18
Lima	ND	ND	ND	[b] ND	[b] 0.38	ND	[a,d] 0.45	[b] 0.50	[c] 1.86	[b] ND	[b] 0.68	[a] 0.36
Chacaltaya	ND	ND	ND	[b,c] 0.62	[b] 0.079	[b] 0.12	ND	ND	[c] 2.99	[b] 0.19	0.213	—
Antofagasta	0.38	0.142	0.227	0.381	0.265	0.256	0.572	0.324	0.496	[b] 0.32	ND	—
Santiago	[b] 0.83	[a] 0.46	[a] 0.98	[b] 0.40	[b,c] 1.5	ND	[b] 0.78	[b] 0.54	ND	ND	—	[a] 0.32
Puerto Montt	[b] 0.57	[b] 0.60	[b] 0.61	ND	[b] 0.62	[b] 0.54	ND	[b,c] 0.71	[a] 0.25	[b] 0.48	ND	0.741
Punta Arenas	ND	[a] 0.50	[b] 0.38	ND	[b,c] 0.90	[a] 0.36	[b] 0.48	[a] 0.13	1.17	ND	[b] 0.37	[b] 0.56

[a] Counting error is 51–100 percent.
[b] Counting error is 20–50 percent.
[c] Data suspect.
[d] Analysis performed by FCRL.
ND, not detectable.

Table 14. Cesium-137 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	51.0	31.1	72.9	73.9	37.7	18.3	18.5	22.1	18.7	14.1	25.3	20.5
Moosonee	25.5	30.9	45.4	61.0	50.1	38.4	28.4	21.3	9.45	9.03	8.19	10.0
Seattle	80.0	31.1	80.0	34.5	31.0	32.6	19.7	—	—	—	—	—
Appleton	36.7	44.2	57.6	69.2	53.4	64.1	49	33.6	11.3	12.6	10.0	12.9
Westwood	54.5	46.5	43.8	56.0	48.1	47.1	—	—	—	—	—	—
New York	42.4	51.3	54.5	73.1	56.5	67.0	55.2	36.2	24.3	19.2	16.4	14.9
	38.4	61.0	53.0	81.0	58.9	69.1	59.6	36.1	21.3	23.6	13.1	15.5
	40.4	56.2	53.8	77.1	57.7	68.0	57.4	36.1	22.8	21.4	14.8	15.2
	±8.8	±15	±2.5	±8.8	±3.6	±2.7	±6.8	±0.24	±13	±18	±20	±3.5
Sterling	39.8	49	42.4	51.2	69.8	51.7	35.3	[a] 27.4	17.2	[a] 11.2	13.8	14.4
Palo Alto	23.2	54.5	81.7	48.9	46.6	29.2	24.9	19.5	24.7	15.3	13.5	13.7
Midwest City	42.5	49.1	65.6	95.8	62	51.6	40.8	26.5	16.2	—	—	—
Norman	—	—	—	—	—	—	—	—	—	22.1	16.3	24.2
Chattanooga	42.9	46.2	50.1	83.6	60.0	36.4	43.0	24.3	17.4	18.3	17.0	24.3
Miami	45.4	47.2	59.0	100	78.0	37.7	19.0	12.7	9.30	13.4	13.9	22.6
Mauna Loa	33.3	75.7	56.9	42.3	24.8	31.2	26.0	15.6	8.6	10.9	7.45	14.9
San Juan	29.0	30.2	31.7	67.3	21.1	26.1	20.1	13.1	5.68	5.63	4.18	7.01
Miraflores	19.4	19.2	29.4	35.5	10.1	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	6.53	9.0	4.41	1.35	[b] 2.89	1.29	5.74
Southern Hemisphere												
Guayaquil	7.50	5.39	3.35	1.92	1.26	1.58	2.99	3.19	2.63	3.78	4.85	4.41
Lima	13.5	29.5	31.8	[a] 19.0	13.4	9.15	[a] 8.05	—	—	[a] 11.7	—	4.1
Chacaltaya	3.86	2.80	4.47	1.87	3.32	2.50	—	—	—	6.7	—	12.2
Antofagasta	20.2	20.8	10.4	9.58	7.09	5.90	11.8	[b] 9.94	19.7	9.48	—	—
Santiago	22.6	16.2	13.4	12.4	8.37	5.29	12.9	12.4	14.6	9.80	—	10.8
Puerto Montt	14.5	13.5	11.2	9.37	5.1	3.88	3.90	5.42	5.25	5.25	4.15	6.65
Punta Arenas	8.07	10.9	8.25	7.16	4.24	2.48	3.40	2.52	6.52	3.16	2.98	4.16

[a] Analysis performed by FCRL.
[b] Data suspect.

Table 15. Cerium-144 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule	182	120	243	173	105	55.5	39.8	43.5	32.0	23.5	39.1	23.9
Moosonee	109	111	144	148	125	100	58	38.3	18.9	14.3	11.4	12.8
Seattle	244	120	244	104	87	123	42.5	34.0	26.4	17.6	15.2	16.4
Appleton	118	150	166	154	195	182	105	64	20.5	21.8	15.6	15.9
Westwood	116	143	135	184	148	152	107	74.7	30.7	25.1	—	—
New York	148	192	150	174	148	187	113	67.0	39.7	29.7	21.8	18.4
	143	181	155	171	141	210	122	62.0	33.0	29.6	20.0	18.5
	146	186	153	172	144	199	118	64.5	36.4	29.7	29.0	18.4
	±3.0	±5.2	±2.9	±1.5	±4.3	±9.7	±6.5	±6.9	±16	±0.29	±7.6	±4.8
Sterling	146	125	156	181	215	155	100	[a] 55.6	[b] 38.3	[c] 19.6	21.4	18.6
Palo Alto	93	188	240	108	157	74.2	50.5	39.4	42	23.6	21.0	17.1
Midwest City	134	162	196	224	151	158	76.3	45.2	26.7	—	—	—
Norman	—	—	—	—	—	—	—	—	—	33.2	25.8	24.0
Chattanooga	144	157	144	137	170	132	88.2	45.2	31.0	28.6	22.8	26.1
Miami	156	168	188	262	189	107	44.5	24.4	21.4	21.7	23.3	25.7
Mauna Loa	116	269	165	101	80.0	87.2	54.6	29.8	15.2	19.7	12.4	17.3
San Juan	110	109	102	176	36.2	92.0	41.5	26.8	9.92	8.89	7.72	8.04
Miraflores	73.6	69.5	74.3	89.3	57.7	—	—	—	—	—	—	—
Balboa	—	—	—	—	—	20.2	20.8	9.08	2.5	2.3	2.39	6.64
Southern Hemisphere												
Guayaquil	21.7	12.1	9.03	16.5	4.13	4.64	4.73	4.59	4.15	6.45	5.81	5.40
Lima	38.2	29.5	31.8	[a] 19.0	13.4	9.15	[a] 15.0	17.6	22.4	[a] 21.3	17.5	12.6
Chacaltaya	11.5	8.5	12.1	5.62	6.01	7.84	[c] 7.7	8.98	13.4	9.62	6.15	—
Antofagasta	54.9	42.9	30.1	25.6	—	16.1	23.9	28.6	42.4	13.1	17.7	—
Santiago	61.1	41.7	37.1	26.7	18.8	13.1	18.5	18.6	22.2	13.7	—	13.3
Puerto Montt	39.0	34.9	28.8	21.6	13.8	10.0	5.9	8.24	8.17	8.38	5.95	13.6
Punta Arenas	22.4	29.9	28.1	16.7	10.2	6.83	5.85	3.55	11.0	[b] 6.64	3.36	[b] 49.2

[a] Analysis performed by FCRL.
[b] Data suspect.
[c] Counting error is 20–50 percent.

Table 16. Plutonium-238 concentrations in surface air, January–December 1965

(concentrations, dpm/1,000,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule								[a] 10	ND	[a] 2.2		7.1
Moosonee											[b] 4.4	9.7
Seattle								ND	ND	ND	ND	[b] 7.4
Appleton											ND	ND
Westwood	[b] 15	ND	[b] 16	67.0	[b] 14	29.6	26.6		[b] 3.9	7.62		
New York						[b] 13			ND	[a] 2.7	[c] 4.8	[b] 17
									ND	[b] 6.1	[c] 3.4	ND
										±4.4	±4.1	
										68	30	
Sterling	[b] 10	[b] 26	22.5	27	22.3	19.6	[b] 15	[c] ND	[b] 5.1	[b,d] 16		[b] 2.6
Palo Alto										ND	[b] 4.6	ND
Midwest City												
Norman												ND
Chattanooga						ND					ND	[a] 3.5
Miami												ND
Mauna Loa												21.3
San Juan											ND	[b] 4.6
Miraflores												
Balboa											ND	[b] 2.6
Southern Hemisphere												
Guayaquil											ND	[b] 4.6
Lima	[b] 5.0	ND	[b] 4.2	[a,c] 5.4	[b] 5.9	[b] 2.4	[c] ND		[b] 4.0		[b] 2.5	[b] 11
Chacaltaya	ND	21.6	[b] 3.5	[a] 4.7	12.5	ND	7.64		[b] 4.8		[b] 5.1	
Antofagasta	[b] 7.7	10.7	28.6	11.7	[b] 7.9	[a] 5.4	[b] 3.6	[b] 3.0	[b] 9.4	ND	8.09	
Santiago												10.8
Puerto Montt										ND	[b] 4.3	ND
Punta Arenas									ND		ND	[b] 4.3

[a] Counting error is 51–100 percent.
[b] Counting error is 20–50 percent.
[c] Analysis performed by FCRL.
[d] Data suspect.
ND, not detectable.

Table 17. Plutonium-239 concentrations in surface air, January–December 1965

(concentrations, dpm/100,000 m³ at midmonth)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Northern Hemisphere												
Thule								16.0	13.5	10.7		12.9
Moosonee											4.43	5.5
Seattle								13.3	10.0		17.4	8.29
Appleton											[a] 3.06	7.09
Westwood	71.7	[b] 74	66.6	[a] 261	66.2	88.6	49.4		18.4	14.7		
New York						48.5			15.0	14.9	10.2	10.1
									13.1	13.4	9.24	7.94
									±14.1	±14.2	±9.72	±9.02
									12	9.4	8.8	22
Sterling	84.4	97.9	60.3	67.6	91.3	78.6	33.6	21	15.4	9.80		9.52
Palo Alto										[a] 8.41	9.80	10.0
Midwest City												
Norman												13.4
Chattanooga						39.0					11.6	11.0
Miami												13.6
Mauna Loa												9.1
San Juan											[a] 1.57	3.14
Miraflores												
Balboa											[a,b] 0.29	2.78
Southern Hemisphere												
Guayaquil											[a,b] 1.4	2.44
Lima	22.3	12.0	12.0	[b] 5.6	7.45	6.47	[b] 5.35		9.42		10.8	7.05
Chacaltaya	3.9	[a] 259	4.29	[b] 3.6	5.36	4.22	4.18		5.35	[a,b] 2.0	3.67	
Antofagasta	31.2	26.4	[a,b] 0.94	9.53	16.5	7.60	8.22	10.8	24.0	[a] 5.83	9.12	
Santiago										[a] 6.26		6.47
Puerto Montt										ND	[a] 1.45	[a] 2.67
Punta Arenas									[a] 25		[a] 0.63	1.86

[a] Data suspect.
[b] Counting error is 20–50 percent.
[c] Counting error is 51–100 percent.
ND, not detectable.

Table 18. Analyses of coded blank and standard samples during 1965

Radionuclide	Sample	Report date: January 15 A[a]	B[a]	C[a]	D[a]	February 15 A[a]	B[a]	C[a]	D[a]
Manganese-54	Added	0	4,450	0	0	134,000	179,000	0	0
	Found	ND	3,200	ND	ND	94,300	143,000	ND	ND
	% Deviation		−28			−30	−20		
Iron-55	Added	0	42,300	0	0	144,000	187,000	0	0
	Found	ND	[b] 4,320	ND	ND	151,000	204,000	[c] 800	ND
	% Deviation					+4.9	+9.1		
Strontium-89	Added								
	Found								
	% Deviation								
Strontium-90	Added	368	2,390	0	0	16,400	2,450	0	0
	Found	391	2,430	6.2	[d] 1.0	13,900	2,180	ND	ND
	% Deviation	+6.2	+1.7			−15	−11		
Zirconium-95	Added	280	0	0	0	0	0	0	0
	Found	290	ND	[c] 10	[c] 12	ND	ND	[c] 4.4	ND
	% Deviation	+3.6							
Cadmium-109	Added	0	0	[a]	0	4,470	10,700	0	0
	Found	ND	ND	ND	ND	4,100	6,240	ND	ND
	% Deviation					−8.3	−42		
Cesium-137	Added	366	4,510	0	0	3,250	3,350	0	0
	Found	370	4,130	[d] 1.9	[d] 2.4	2,960	2,880	[d] 0.99	ND
	% Deviation	+1.1	−8.4			−8.9	−14		
Cerium-144	Added	4,000	0	0	0	7,280	8,130	0	0
	Found	3,870	[d] 5.7	[d] 1.9	16	6,760	7,800	35	10
	% Deviation	−3.2				−9.8	−4		
Plutonium-238	Added								
	Found								
	% Deviation								
Plutonium-239	Added								
	Found								
	% Deviation								

Radionuclide	Sample	March 15 A	B	C	D	April 15 A	B	C
Manganese-54	Added	0	104,000	0	103,000	0	0	0
	Found	ND	88,200	[d] 709	77,100	ND	[c] 210	ND
	% Deviation		−15		−25			
Iron-55	Added	106,000	199,000	0	0	109,000	0	0
	Found	[b] 9,520	[b] 16,700	ND	[d] 320	94,300	[d] 780	[c] 390
	% Deviation					−13		
Strontium-89	Added					39,700		
	Found					32,300		
	% Deviation					−19		
Strontium-90	Added	0	2,160	15,300	0	5,720	0	0
	Found	ND	1,980	13,800	1.6	6,150	1.6	ND
	% Deviation		−8.3	−9.8		+7.5		
Zirconium-95	Added		27,500		10,700			
	Found		[b] 54,600		[b] 23,100			
	% Deviation		+98		+116			
Cadmium-109	Added	0	999	7,120	0	4,240	0	0
	Found	[c] 30	859	6,240	[c] 12	2,440	ND	ND
	% Deviation		−14	−12		−42		
Cesium-137	Added	0	7,710	0	1,710	0	0	0
	Found	3.24	7,100	[d] 2.2	1,610	4.51	6.56	4.46
	% Deviation		−7.9		−5.8			
Cerium-144	Added	0	12,900	0	9,720	0	0	0
	Found	28.8	13,100	19.8	8,160	32.4	20.5	ND
	% Deviation		+1.5		−16			
Plutonium-238	Added							
	Found							
	% Deviation							
Plutonium-239	Added							
	Found							
	% Deviation							

See footnotes at end of table.

Table 18. Continued—Analyses of coded blank and standard samples during 1965

Radionuclide	Sample	Report date: May 15 A	May 15 B	May 15 C	May 15 D	June 15 A	June 15 B	June 15 C	June 15 D
Manganese-54	Added	0	246,000	0	246,000	0	170,000	0	236,000
	Found	ND	283,000	ND	216,000	ND	116,000	ND	185,000
	% Deviation		+15		−12		−32		−22
Iron-55	Added	136,000	0	0	92,300	22,200	0	0	177,000
	Found	104,000	ND	[c] 400	96,000	30,800	ND	ND	161,000
	% Deviation	−24			+4	+39			−9
Strontium-89	Added	0	0	0	0	0	0	0	0
	Found	ND	ND	ND	[d] 540	ND	ND	ND	ND
	% Deviation								
Strontium-90	Added	0	0	4,460	5,470	0	0	7,910	6,840
	Found	ND	ND	4,320	4,820	ND	ND	[b] 3,140	6,690
	% Deviation			−3.1	−12			−60	−2.2
Zirconium-95	Added	0	3,640	0	3,510	0	1,950	0	2,480
	Found	ND	2,830	ND	3,030	25	1,880	ND	2,150
	% Deviation		−22		−14		−3.6		−13
Cadmium-109	Added	0	0	1,990	1,660	0	0	4,050	3,860
	Found	[c] 32	ND	1,960	932	[c] 32	[c] 13	2,100	2,710
	% Deviation			−1.5	−44			−48	−30
Cesium-137	Added	0	1,660	0	1,850	0	3,550	0	6,080
	Found	ND	[b] 935	ND	1,390	[c] 0.65	3,100	[d] 1.6	4,740
	% Deviation		−44		−25		−13		−22
Cerium-144	Added	0	8,680	0	23,500	0	14,500	0	17,000
	Found	[c] 3.6	7,770	140	[b] 7,560	ND	[b] 5,960	ND	15,500
	% Deviation		−10		−68		−59		−8.8
Plutonium-238	Added					0	0		0
	Found					ND	ND		ND
	% Deviation								
Plutonium-239	Added					15.6	0		33.9
	Found					9.01	ND		16.1
	% Deviation					−42			−53

Radionuclide	Sample	July 15 A	July 15 B	July 15 C	August 15 A	August 15 B	August 15 C
Manganese-54	Added	0	66,600	0	29,500	0	32,400
	Found	ND	42,400	ND	26,800	ND	29,400
	% Deviation		−36		−9.2		−9.3
Iron-55	Added	0	25,700	0	0	29,100	36,000
	Found	[c] 410	22,500	ND	[d] 240	25,000	29,400
	% Deviation		−13			−14	−18
Strontium-89	Added	0	3,810	0			
	Found	ND	3,660	[d] 5.46			
	% Deviation		−3.9				
Strontium-90	Added	0	913	0	484	468	0
	Found	0.63	884	[c] 3.99	470	459	0.989
	% Deviation		−3.2		−2.9	−1.9	
Zirconium-95	Added	0	1,120	0			
	Found	275	1,464	ND			
	% Deviation		+31				
Cadmium-109	Added	0	1,130	0	438	523	0
	Found	ND	840	[c] 8.8	102	482	ND
	% Deviation		−29		−77	−7.8	
Cesium-137	Added	[c] 0	29,700	0	3,300	0	4,160
	Found	2.61	28,900	1.68	3,330	3.11	4,260
	% Deviation		−2.7		+0.91		+2.4
Cerium-144	Added	0	5,220	0	1,560	0	1,550
	Found	ND	4,800	ND	1,440	ND	1,420
	% Deviation		−8		−7.7		−8.4
Plutonium-238	Added	0	0	0		0	0
	Found	ND		[c] 0.10		1.94	ND
	% Deviation						
Plutonium-239	Added	0	68.3	0		15.1	8.77
	Found	ND		ND		6.88	5.59
	% Deviation					−54	−36

See footnotes at end of table.

Table 18. Continued—Analyses of coded blank and standard samples during 1965

Radionuclide	Sample	Report date: September 15 A	B	C	D	October 15 A	B	C	D
Manganese-54	Added	0		44,900	35,300		0	31,900	0
	Found	[a] 380		44,700	29,500		[a] 198	33,400	ND
	% Deviation			−0.45	−16			+4.7	
Iron-55	Added	64,500	32,200	0	0		40,400	0	33,200
	Found	63,600	32,800	ND	ND		32,200	ND	30,800
	% Deviation	−1.4	+1.9				−20		−7.2
Strontium-89	Added								
	Found								
	% Deviation								
Strontium-90	Added	217	206	0	0	0	302	0	
	Found	210	197	0.504	0.195	5.04	292	ND	318
	% Deviation	−3.2	−4.4				−3.3		291
									−8.5
Zirconium-95	Added								
	Found								
	% Deviation								
Cadmium-109	Added	324	347	0	0		310	0	
	Found	308	324	ND	ND		[d] 253	ND	480
	% Deviation	−4.9	−6.6				−18		314
									−35
Cesium-137	Added	0	0	377	371	432	0	358	
	Found	[a] 1.6	ND	378	351	500	[a] 1.01	374	0
	% Deviation			+0.27	−5.4	+16		+4.5	1.03
Cerium-144	Added	0	0	546	609	733	0	691	
	Found	[a] 0.96	ND	525	554	710	[a] 1.45	656	0
	% Deviation			−3.8	−9.0	−3.1		−5.1	ND
Plutonium-238	Added	0	0	0	0	0	0	0	
	Found	ND	[d] 0.738	ND	ND	ND	ND	ND	0
	% Deviation								ND
Plutonium-239	Added	11.7	13.1	0	0	0	20.5	0	
	Found	6.28	5.41	ND	ND	ND	13.1	ND	15.2
	% Deviation	−46	−59				−36		10.1
									−34

Radionuclide	Sample	November 15 A	B	C	D	December 15 A	B	C	D	Average percent deviation
Manganese-54	Added	44,200	0	23,700	0	47,400	0	47,700	0	
	Found	5,130	ND	26,400	ND	47,400	ND	48,800	ND	
	% Deviation	−88		+11		+0		+2.3		−16
Iron-55	Added	0	8,830	0	12,700	0	9,100	0	11,600	
	Found	ND	7,480	[d] 1,830	9,560	[d] 180	6,720	ND	9,280	
	% Deviation		−15		−25		−26		−20	−8.2
Strontium-89	Added									
	Found									
	% Deviation									−11
Strontium-90	Added	0	230	0	241	0	221	0	206	
	Found	[d] 0.98	214	[d] 0.97	200	[a] 0.41	210	[d] 2.5	204	
	% Deviation		−7		−17		−5		−0.9	−4.9
Zirconium-95	Added									
	Found									
	% Deviation									−3
Cadmium-109	Added	0	460	0	491	0	332	0	396	
	Found	ND	429	ND	358	ND	338	ND	104	
	% Deviation		−6.7		−27		+1.8		−74	−26
Cesium-137	Added	694	0	453	0	472	0	527	0	
	Found	779	ND	494	ND	508	ND	600	ND	
	% Deviation	+12		−9.1		+7.6		+16		−2.2
Cerium-144	Added	525	0	567	0	590	0	949	0	
	Found	529	[a] 0.80	555	[a] 9.2	570	ND	823	ND	
	% Deviation	+0.8		−2.1		−3.4		−13		−6.3
Plutonium-238	Added	0	0	0	0	0	0	0	0	
	Found	[a] 0.037	ND		0.135	[d] 0.90	[a] 0.092	[d] 0.23	0.528	
	% Deviation									
Plutonium-239	Added	0	15.8		17.7	0	13.1	0	15.3	
	Found	ND	3.99		2.57	[a] 0.10	7.90	ND	9.88	
	% Deviation		−75		−85		−40		−36	−48

[a] Figures in table are in units of dpm with percent deviation of "found" from "added" values.
[b] Suspect data. Percent standard deviation is not included in average value for radionuclide.
[c] One standard deviation of counting error is between ±51–100 percent.
[d] One standard deviation of counting error is between ±20–50 percent.

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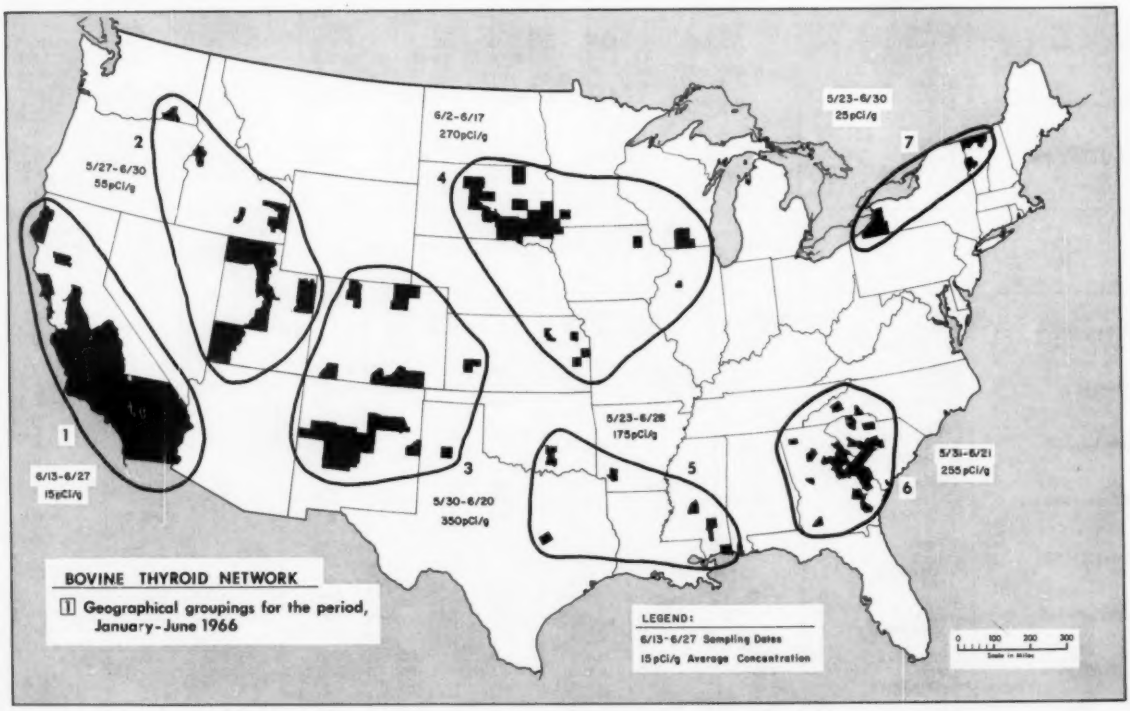

Figure 1. Counties sampled in bovine thyroid network, January–June 1966

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

IODINE-131 IN BOVINE THYROIDS, JANUARY–JUNE 1966

National Center for Radiological Health
Public Health Service

To supplement its existing environmental surveillance systems, the National Center for Radiological Health established a Bovine Thyroid Network in October 1964 (*1*). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed by gamma-ray spectrometry for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear test sites. Details of sampling and analysis have been published earlier (*1*). For this report, the collection areas sampled during January through June 1966 were grouped on a broad geographical basis as shown in figure 1.

The results for January through June 1966 appear in table 1 and are listed chronologically within the geographical groupings noted in figure 1. The influx of fallout iodine–131 following the mainland China atmospheric nuclear detonation of May 9, 1966, was observed through June 1966, with peak values for individual specimens ranging from 100 to 900 pCi iodine–131/g thyroid in the various geographical groupings during the early and middle part of June 1966.

To indicate the relative occurrence of iodine–131 in the bovine thyroid for the geographical groupings selected, average observed concentrations (pCi iodine–131/g thyroid) have been calculated for each of the seven groupings. These averages are calculated for the periods of time (shown in figure 1) during which the iodine–131 levels were at their peak or, in the cases where peak values were not observed, for the period during which the counties were sampled after the detonation event. The average values indicate the relative intakes for the bovine populations in each of the geographical groupings. Groupings 1 (California), 2 (Idaho, Utah, and Washington), and 7 (New York and Vermont) reflected low intakes for the bovine populations (15, 55, and 25 pCi/g thyroid, respectively). Considerably higher thyroid concentrations were observed in the remaining four groupings (175–350 pCi/g thyroid).

Recent coverage in Radiological Health Data and Reports:

Period	Issue
January–June 1965	January 1966
July–December 1965	October 1966

REFERENCE

(1) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine–131 in bovine thyroid, October–December 1964. Radiol Health Data 6:569–574 (October 1965).

Table 1. Iodine-131 in bovine thyroids, January–June 1966

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
1 California	[b] 1/3–5/13	[California] [a]: Fresno (23) [a], Glenn (0), Humboldt (4), Imperial (1), Kern (3), Kings (15), Los Angeles (91), Madera (4), Marin (2), Merced (46), Monterey (26), Orange (0), Riverside (13), Sacramento (0), San Benito (2), San Bernardino (25), San Diego (1), San Joaquin (49), San Luis Obispo (5), San Mateo (0), Santa Barabara (7), Sonoma (4), Stanislaus (37), Tulare (20), Ventura (2)	380	[d] ND		
	5/17	Kern	1	10		
		San Bernardino	2	ND		
	5/18	Los Angeles	3	10	ND	17
		San Joaquin	4	8	5	13
		Stanislaus	2	4	ND	7
	5/19	Fresno	2	ND		
		Los Angeles	2	5	3	6
		San Joaquin	2	1	ND	2
	5/20	Glenn	2	1	ND	2
	5/23	Los Angeles	1	10		
		Monterey	2	30	5	54
		San Joaquin	2	15	13	16
		Stanislaus	2	8	7	8
	5/24	Los Angeles	3	7	ND	20
		Merced	2	2	ND	4
		San Bernardino	2	ND		
		San Joaquin	2	26	14	38
	5/25	Los Angeles	2	ND		
		San Mateo	1	ND		
	5/27	Kings	1	3		
		San Luis Obispo	2	8	6	9
		Tulare	1	5		
	5/31	Madera	2	ND		
		Monterey	2	49	3	95
		Stanislaus	2	7	ND	13
	6/1	Los Angeles	2	8	5	10
		Orange	2	1	ND	2
		San Joaquin	2	2	ND	3
		Stanislaus	2	5	4	6
	6/3	Los Angeles	4	<1	ND	3
	6/6	Monterey	2	3	ND	6
		San Joaquin	2	2	ND	4
		Stanislaus	2	5	4	5
	6/7	Merced	2	9	ND	18
		San Joaquin	2	1	ND	2
	6/8	Los Angeles	2	6	6	6
		San Bernardino	2	4	3	4
	6/10	Fresno	1	ND		
		Tulare	1	3		
		Ventura	2	16	14	17
	6/13	Madera	2	2	ND	4
		Merced	2	24	22	25
		Monterey	2	2	2	2
	6/14	Merced	4	4	ND	13
	6/15	Los Angeles	2	11	ND	21
	6/16	Fresno	1	4		
		Stanislaus	1	13		
	6/17	San Bernardino	2	12	ND	24
	6/20	Monterey	2	56	6	106
		Sacramento	2	38	ND	75
		Stanislaus	2	14	3	25
	6/21	San Joaquin	2	24	19	29
		Stanislaus	2	40	34	46
	6/22	Los Angeles	4	1	ND	3
		San Bernardino	2	5	4	5
	6/24	Fresno	1	9		
		Kern	3	ND		
		Madera	1	6		
	6/27	Madera	2	22	ND	44
		Sacramento	1	28		
		Stanislaus	2	8	5	10
	6/28	Los Angeles	2	2	ND	3
	6/29	Los Angeles	2	3	ND	5
	6/30	Fresno	4	7	3	9
2 Idaho, Utah, and Washington	[b] 1/4–4/22	[Idaho] [a]: Adams (0) [a], Bonneville (0), Caribou (0), Minidoka (0); [Utah]: Beaver (0), Box Elder (0), Cache (0)	47	[d] ND		

See footnotes at end of table.

Table 1. Continued—Iodine-131 in bovine thyroids, January–June 1966

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
2 Continued.		[Utah]				
		Davis (0)	Unitah (0)			
		Iron (0)	Utah (0)			
		Morgan (0)	Washington (0)			
		Salt Lake (0)	Weber (5)			
		Sanpete (0)	[Washington]			
		Sevier (0)	Walla Walla (42)			
	5/27	Beaver	2	13	7	18
		Bonneville	1	2		
		Salt Lake	2	254	48	460
		Sevier	3	7	ND	14
		Utah	1	51		
		Washington	1	25		
	6/1	Box Elder	1	ND		
		Walla Walla	8	12	ND	36
		Weber	4	44	ND	129
	6/7	Cache	1	ND		
		Bonneville	1	166		
		Sanpete	3	12	10	15
	6/8	Walla Walla	7	38	8	93
	6/11	Adams	10	37	16	89
	6/13	Cache	4	59	19	114
	6/14	Caribou	1	125		
		Davis	1	6		
		Utah	2	48	5	91
		Weber	1	237		
	6/18	Adams	10	95	80	119
	6/24	Iron	1	18		
		Sevier	4	39	5	74
	6/27	[Idaho] [f]	5	74	29	103
	6/28	Box Elder	3	9	8	10
		Minidoka	1	6		
		Unitah	1	55		
	6/30	Box Elder	1	73		
		Morgan	1	233		
		Weber	8	72	ND	215
3 Colorado, New Mexico, northwestern Texas, and western Kansas	[b] 1/3–5/3	[Colorado] [e]	140	[d] ND		
		Costilla (4) [e]	San Miguel (8)			
		La Plata (12)	Socorro (0)			
		Las Animas (4)	Torrance (4)			
		Routt (4)	Valencia (12)			
		Weld (0)	[Texas]			
		[New Mexico]	Swisher (0)			
		Bernalillo (60)	[Kansas]			
		Curry (32)	Finney (0)			
	5/9	Bernalillo	4	6	ND	17
	5/10	Socorro	4	5	3	6
	5/16	Valencia	4	3	ND	9
	5/17	Valencia	4	12	10	15
	5/23	La Plata	4	29	7	55
	5/24	Valencia	4	17	12	25
		Finney	1	4		
	5/30	Costilla	4	92	8	327
	5/31	Bernalillo	4	200	156	247
	6/6	Valencia	4	534	13	762
	6/7	Costilla	4	457	38	881
	6/13	Valencia	4	593	407	793
	6/14	Valencia	4	435	349	493
	6/20	Curry	4	137	69	208
	6/21	Curry	4	69	7	152
		Weld	1	8		
	6/27	Bernalillo	4	13	ND	31
	6/28	Valencia	4	65	42	97
	6/30	Swisher	1	ND		
4 Illinois, Iowa, Kansas, Minnesota, South Dakota, and Wisconsin	[b] 1/4–5/3	[Illinois] [e]	216	[d] ND		
		Stark (0) [e]	[South Dakota]			
		[Iowa]	Aurora (0)			
		Fayette (2)	Beadle (0)			
		Lyon (11)	Brookings (1)			
		[Kansas]	Brown (6)			
		Anderson (0)	Brule (3)			
		Finney (0)	Charles Mix (6)			
		Jefferson (0)	Davison (1)			
		Miami (0)	Dewey (10)			
		Riley (0)	Douglas (3)			
		[Minnesota]	Gregory (10)			
		Rock (11)	Hanson (5)			
		Murray (0)	Hutchinson (10)			

See footnotes at end of table.

Table 1. Continued—Iodine-131 in bovine thyroids, January–June 1965

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
4 Continued.		[South Dakota] Lake (0), Lincoln (2), Lyman (1), McCook (0), Miner (5), Minnehaha (10), Moody (1), Stanley (10), Sully (5), Turner (17) [Wisconsin] Rock (46), Dane (29), Green (11)				
	5/9	Brown	6	3	ND	4
		McCook	1	ND		
		Minnehaha	3	ND		
	5/13	Dane	1	ND		
		Rock	1	ND		
	5/17	Dane	2	ND		
		Lyon	1	20		
	5/18	Minnehaha	1	2		
		Rock	1	10		
	5/19	Anderson	2	6	5	7
		Miami	1	21		
	5/20	Beadle	4	<1	ND	3
		Rock	4	4	2	6
	5/24	Brookings	6	5	ND	11
	5/26	Dane	2	8	7	8
	5/27	Green	5	127	72	198
	6/1	Lake	1	5		
		McCook	1	7		
		Minnehaha	3	141	51	255
		Murray	2	2	2	2
	6/2	Miner	2	166	56	276
		Stark	11	413	312	558
	6/6	Jefferson	1	212		
	6/9	Aurora	6	237	4	638
	6/10	Dane	2	19	13	24
	6/14	Aurora	3	235	134	286
		Brookings	2	206	ND	412
		Minnehaha	3	531	184	814
	6/16	Dane	2	48	43	53
	6/17	Riley	3	40	30	49
	6/22	Riley	1	9		
	6/23	Dane	1	5		
		Rock	1	12		
	6/29	Dane	5	25	ND	48
	6/30	Rock	2	20	15	25
5 Arkansas, Mississippi, Oklahoma and eastern Texas	5/9–5/16 [b]	[Arkansas] [c] Hempstead (2) [d] [Mississippi] Forrest (12), Jackson (0), Jones (0), Rankin (0) [Oklahoma] Pontotoc (6), Johnston (2) [Texas] Falls (1)	23	[e] ND		
	5/23	Forrest	6	18	3	50
	6/1	Jackson	5	485	189	883
		Rankin	1	402		
	6/7	Forrest	6	206	110	327
	6/16	Jackson	6	151	95	251
	6/21	Jones	5	73	ND	142
	6/28	Forrest	5	85	69	101
6 Georgia, North Carolina, and South Carolina	1/5–5/16 [b]	[Georgia] [c] Bulloch (1) [d], Burke (0), DeKalb (0), Elbert (0), Gordon (1), Greene (0), Gwinnett (0), Hancock (1), Jenkins (1), Jefferson (3), Lincoln (2), McDuffie (2), Mitchell (2), Morgan (2), Richmond (0), Screven (1), Taliaferro (1), Tattnell (1), Toombs (3), Upson (1), Washington (5), Warren (4), Wayne (0), Wilkes (3) [North Carolina] Buncombe (0), Cleveland (2) [South Carolina] Aiken (0), Chester (0), Greenwood (0), Lexington (0), Richland (2), Saluda (0), Spartanburg (0)	38	ND		
	5/17	Cleveland	3	6	2	11
		Richmond	1	[f] ND		
		Screven	3	ND		
		Warren	1	ND		

See footnotes at end of table.

Table 1. Continued—Iodine-131 in bovine thyroids, January–June 1966

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
6 Continued.	5/24	Chester	3	34	2	70
		Greene	1	150		
		Greenwood	2	89	36	141
		Morgan	2	ND		
		Screven	1	5		
		Wilkes	1	150		
	5/30	Jefferson	1	8		
		Morgan	1	ND		
	5/31	Aiken	1	145		
		Cleveland	1	48		
		Greene	1	149		
		Saluda	1	624		
		Screven	2	627	524	729
		Wilkes	2	582	349	815
	6/13	Greene	4	188	44	360
		Lexington	2	223	145	301
		Spartanburg	4	292	171	590
	6/16	Elbert	1	243		
		Gwinnett	1	702		
		Warren	1	160		
		Wilkes	2	296	244	348
	6/17	Buncombe	3	123	36	285
		Spartanburg	2	39	24	54
	6/20	Greene	2	130	109	151
	6/21	Burke	2	85	59	131
		Lexington	1	167		
		Saluda	1	190		
	6/22	Burke	1	66		
		DeKalb	1	59		
		Warren	1	39		
		Wayne	1	276		
	6/27	Burke	1	2		
		Greenwood	2	39	38	39
		Screven	1	280		
	6/28	Green	2	107	91	123
		Saluda	2	84	44	124
		Warren	1	118		
		Wilkes	1	89		
	6/30	Elbert	1	56		
		Taliaferro	1	36		
7 New York and Vermont	1/6–5/21 [b]	[New York] [c] Cattaraugus (62) [d] Chautauqua (10) Erie (26) Franklin (173) [Vermont] Grande Isle (0) Addison (8) Orkans (2)	281	[e] ND		
	5/23	Franklin	10	11	ND	48
	5/25	Chautauqua	10	63	ND	261
	5/31	Franklin	9	ND		
	6/2	Chautauqua	10	24	ND	115
		Erie	3	45	13	88
	6/6	Franklin	5	53	2	120
	6/8	Chautauqua	10	39	ND	95
	6/9	Erie	7	33	ND	67
	6/14	Chautauqua	3	54	ND	118
		Franklin	10	ND		
	6/16	Chautauqua	7	33	ND	89
		Erie	6	49	ND	131
	6/20	Franklin	2	59	24	94
	6/22	Chautauqua	10	50	4	83
		Franklin	7	14	ND	26
		Grande Isle	1	13		
	6/23	Erie	4	28	7	45
	6/29	Chautauqua	10	20	8	39
		Franklin	10	ND		
	6/30	Erie	5	14	4	20

[a] Geographical areas as designated in figure 1, encompassing those counties that were sampled in the States indicated.
[b] Samples were not collected on all dates during this period, but the interval includes several sampling dates.
[c] Brackets give State and are followed by counties sampled during the period indicated or on some other date during January–June 1966.
[d] The results for this period were for the most part not detectable. Some positive results were obtained, but represented barely detectable amounts of iodine-131 in the bovine thyroid. In general, these positive results were 2–7 pCi/g thyroid and randomly scattered over the time period and counties indicated.
[e] Numbers in parentheses represent the number of samples collected from each county during the interval indicated. These may have been collected over several dates during the period or on only one date. (0) indicates that the county was not sampled during the interval given but was sampled on another date during January–June 1966.
[f] The State is given, but the exact county is unknown. The county is most likely one of those listed under the time interval 1/4–4/22.
ND, not detectable; the two standard deviation counting error was greater than or equal to the concentration observed. For the counting system utilized and these very low concentrations the two standard deviation counting errors were generally 1–3 pCi/g thyroid.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of the environmental radioactivity data follow for the Oak Ridge Gaseous Diffusion Plant, Paducah Plant, and the Portsmouth Area Gaseous Diffusion Plant.

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Oak Ridge Area January–June 1966 [2]

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge area is a complex made up primarily of the Y–12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion-exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

[2] Summarized from Environmental Levels of Radioactivity for the Oak Ridge Area, compiled by the Health Physics and Safety Section of the Health Physics Division, Oak Ridge National Laboratory.

Air Monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of east Tennessee is monitored by two systems of monitoring stations. One system consists of eight stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 1. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

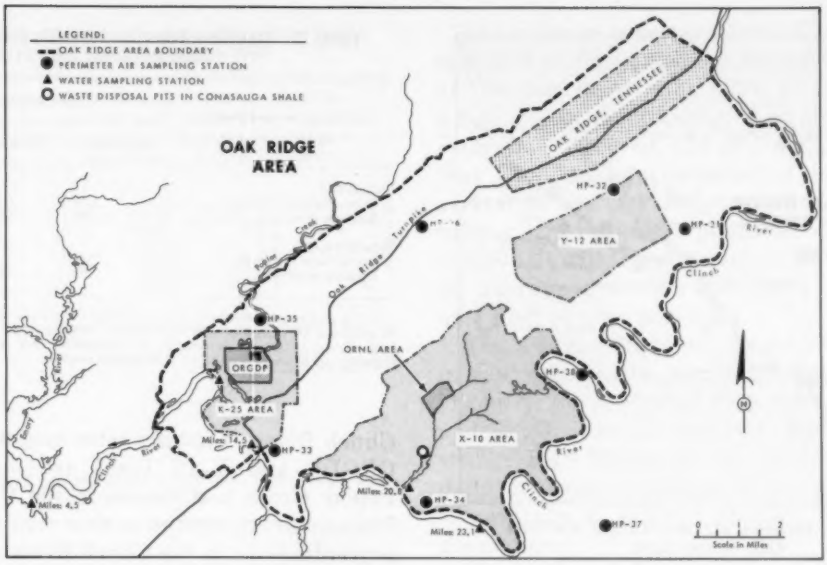

Figure 1. Oak Ridge Area environmental sampling locations

Table 1. Long-lived gross beta and alpha radioactivity in particulates in air Oak Ridge area, January–June 1966

Station number	Number of samples	Beta activity		Alpha activity	
		Average concentration (pCi/m³)	Percent of AEC standard	Average concentration (pCi/m³)	Percent of AEC standard
Perimeter stations [a]					
HP–31	26	0.12	0.12	0.006	0.30
HP–32	26	0.11	0.11	0.006	0.30
HP–33	26	0.09	0.09	0.005	0.25
HP–34	26	0.10	0.10	0.006	0.30
HP–35	26	0.12	0.12	0.006	0.30
HP–36	178	0.18	0.18	0.014	0.70
HP–37	26	0.08	0.08	0.004	0.20
HP–38	26	0.13	0.13	0.006	0.30
Average		0.12	0.12	0.007	0.35
Remote stations [b]					
HP–51	26	0.11	0.11	0.003	0.15
HP–52	26	0.12	0.12	0.004	0.20
HP–53	26	0.12	0.12	0.004	0.20
HP–54	26	0.11	0.11	0.004	0.20
HP–55	26	0.11	0.11	0.003	0.15
HP–56	25	0.12	0.12	0.004	0.20
HP–57	26	0.11	0.11	0.003	0.15
HP–58	25	0.12	0.12	0.004	0.20
Average		0.12	0.12	0.004	0.20

[a] See figure 1.
[b] See figure 2.

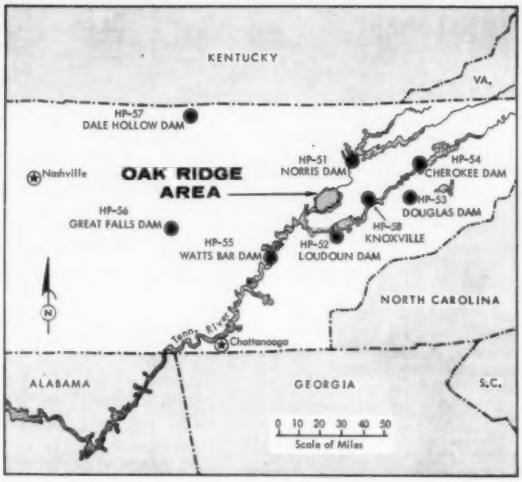

Figure 2. Remote air monitoring stations Oak Ridge Area

Milk monitoring

Raw milk is monitored for iodine–131 and strontium–90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine–131 and strontium–90 detected in raw milk samples during the period are given in table 2.

Water monitoring

Large-volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Table 2. Radionuclides in raw milk, Oak Ridge area January–June 1966

Radionuclide and location	Concentration, pCi/liter		
	Maximum	Minimum *	Average
Iodine-131			
Immediate environs	124	<10	10
Remote environs	30	<10	6.3
Strontium-90			
Immediate environs	64	7.7	25
Remote environs	39	16	23

* The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream-gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, uranium, and the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 3 for the period from January through June 1966.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 4 in terms of mR/hr.

Table 3. Concentrations of major radionuclides in the Clinch River, January–June 1966

Radionuclide	Average concentration, pCi/liter		
	Mile 23.1 [a] (upstream)	Mile 20.8 [a b] (outfall)	Mile 4.5 [a] (downstream)
Strontium-90	1.3	1.5	2.9
Cerium-144	0.4	<0.1	1.0
Cesium-137	0.5	0.9	1.3
Ruthenium-106	1.1	11.0	5.9
Cobalt-60	ND	5.3	6.1
Zirconium-niobium-95	ND	<0.1	<0.1
Gross beta	3.3	110	17

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River (figure 1).
[b] The concentrations at mile 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution afforded by the river.
ND, none was detected.

Table 4. External gamma radiation levels, Oak Ridge area January–June 1966

Location	Average dose rates (mR/hr)
Solway Gate	0.012
Y–12, East Portal	0.011
Newcomb Road	0.011
Gallaher Gate	0.013
White Wing Gate	0.012
Average	0.012

Discussion of data

The average air-contamination levels for gross beta particle activity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 1 and 2) were 0.12 percent of the AEC standard for populations in the neighborhood of a controlled area. These values are approximately one-third higher than those for the last half of 1965. The higher levels may be attributed to an increase in fallout from weapons testing.

The average air-contamination levels for gross alpha particle activity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.35 percent and 0.25 percent, respectively, of the AEC standard for natural uranium for application to populations in the neighborhood of a controlled area.

The average concentration of iodine–131 in air in the immediate environs of the plants was 0.016 pCi/m^3. This is approximately 0.016 percent of the AEC standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine–131 in raw milk in the immediate and remote environs of the Oak Ridge area were 10 pCi/liter and 6.3 pCi/liter, respectively. The maximum concentration observed, 124 pCi/liter, occurred on May 25, 1966, approximately 3 days after the arrival in the Oak Ridge area of fallout containing fresh fission products. The average values fall within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium–90 in raw milk in the immediate and remote environs of the controlled area were 25 pCi/liter and 23 pCi/liter, respectively. These levels fall within FRC Range II for transient rates of daily intake of strontium–90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 110 pCi/liter and 17 pCi/liter, respectively. These values are 2.8 percent and 1.1 percent of the weighted average AEC standards. The average concentration of transuranic alpha emitters in the Clinch River at mile 20.8 was 0.12 pCi/liter, which is approximately 0.003 percent of the weighted average AEC standard.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was <0.01 percent of the AEC standard for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.012 mR/hr, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Conclusion

Surveillance of the radioactivity in the Oak Ridge environs indicated that the major part of the radioactivity detected continues to be the result of fallout from weapons testing. While some low-level radioactivity is being released to the environment from plant operations, the resulting concentrations in both the atmosphere and surface streams of the Oak

Ridge environment are well below established AEC standards for the neighboring population.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1964	January 1965
July–December 1964	July 1965
January–June 1965	January 1966
July–December 1965	September 1966

2. Paducah Plant
January–June 1966 [3]

Union Carbide Corporation
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. A former source of diffusion plant feed, the uranium hexafluoride manufacturing plant, was placed on standby in June 1964. Parts of the associated uranium metal foundry are operated infrequently as the need arises; otherwise, it is also on standby status. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, or ballasts, or other shapes on a non-routine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium–234 and protractinium–234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Because of the necessity for health protection in process areas, the high intrinsic value of uranium, and the desire to maintain a wholesome relationship with neighboring communities and individuals, the Paducah Plant provides confinement and recovery to the greatest extent feasible.

An environmental monitoring system checks the effectiveness of the confinement and recovery systems of the plant. The environmental monitoring program provides for continuously sampling the air at four stations around the plant-perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 3). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma-radiation readings are taken each month at each of the air-sampling stations with a Geiger-Mueller-type meter at a distance of 3 feet above ground level.

Basic standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those listed in the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area, which have resulted from operations within that controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radionuclides in air or water outside a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

[3] Summarized from "Environmental Concentrations of Radioactive Materials near the Paducah Plant—Report for the First Half of 1966."

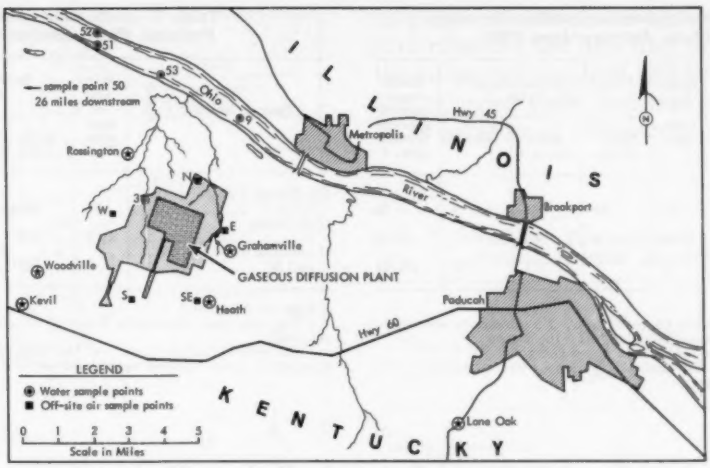

Figure 3. Sampling locations, Paducah Plant

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 5 through 8.

Air samples were collected continuously at each of the four stations at the plant-perimeter fence and at five stations at about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch-diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha particle count—interpreted as uranium, the most likely source of activity—

Table 5. Uranium radioactivity in outdoor air samples Paducah Plant, January–June 1966

Sample location [a]	Number of samples	Uranium alpha radioactivity [b] (pCi/m³)			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
At plant perimeter fence					
North	26	0.08	<0.02	<0.02	<1
East	26	0.07	<0.02	<0.02	<1
South	26	0.02	<0.02	<0.02	<1
West	26	0.05	<0.02	<0.02	<1
Totals	104	0.08	<0.02	<0.02	<1
About 1 mile outside plant perimeter fence					
North	26	0.06	<0.02	<0.02	<1
East	26	0.05	<0.02	<0.02	<1
South	25	0.05	<0.02	<0.02	<1
West	26	0.08	<0.02	<0.02	<1
Southeast	26	0.10	<0.02	<0.02	<1
Totals	129	0.10	<0.02	<0.02	<1

[a] See map, figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/sec.
[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.
[d] The concentration limit for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Table 6. Beta radioactivity in outdoor air samples Paducah Plant, January–June 1966

Sample location [a]	Number of samples	Beta radioactivity (pCi/m³)			Mean as percent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
At plant perimeter fence					
North	26	0.98	<0.1	0.17	0.02
East	26	1.2	<0.1	0.19	0.02
South	26	0.40	<0.1	0.13	0.01
West	26	0.50	<0.1	0.16	0.02
Totals	104	1.2	<0.1	0.17	0.02
About 1 mile outside plant perimeter fence					
North	26	0.54	<0.1	0.16	0.02
East	26	0.35	<0.1	0.14	0.01
South	25	0.63	<0.1	0.15	0.02
West	26	0.35	<0.1	0.16	0.02
Southeast	26	1.9	<0.1	0.23	0.02
Totals	129	1.9	<0.1	0.17	0.02

[a] See map, figure 3.
[b] The minimum detectable amount of beta emitters in air is 0.1 pCi/m³.
[c] The concentration limit applicable to this table is 1,000 pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

Table 7. Concentrations of uranium in water Paducah Plant, January–June 1966

Sample location [a]	Number of samples	Uranium concentration [b] (pCi/liter)			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
Big Bayou Creek 3	26	26	<1	9	0.05
Ohio River 9	6	1	<1	<1	<0.01
Composite of 50, 51, 52, and 53	6	1	<1	<1	<0.01

[a] See map, figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 dis/sec.
[c] The minimum detectable uranium in water is 1 pCi/liter.
[d] The concentration limit for natural uranium in water beyond a controlled area is 20,000 pCi/liter.

Table 8. Beta radioactivity in water Paducah Plant, January–June 1966

Sample location [a]	Number of samples	Beta radioactivity (pCi/liter)			Mean as percent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
Big Bayou Creek 3	26	600	<100	100	0.5
Ohio River 9	6	100	<100	100	0.5
Composite of 50, 51, 52, and 53	6	500	<100	200	1

[a] See map, figure 3.
[b] The minimum detectable amount of beta emitters in water is 100 pCi/liter.
[c] The concentration limit for the immediate daughter products of uranium in water released to the environs is 20,000 pCi/liter.

of the 233 air samples collected during the first half of 1966 was less than 1 percent of the concentration limit set for individuals residing in the vicinity of a controlled area. The mean beta-particle count of the same samples was 0.02 percent of the concentration limit.

The average uranium analysis of weekly water samples collected continuously from the Big Bayou during the first half of 1966 was 0.05 percent of the concentration limit for water beyond a controlled area. The results of the uranium analyses for each of the six grab samples collected at monthly intervals from the Ohio River below the plant were equal to or less than 0.01 percent of the concentration limit.

The concentration of beta emitters in the Big Bayou averaged 0.5 percent of the concentration limit for the decay products of uranium–238 during the first half of 1966. The beta-particle activity of the Ohio River averaged 1 percent of the concentration limit for uranium–238 decay products during the period.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hour at all sampling stations for the first half of 1966.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1964	February 1965
1964	July 1965
January–June 1965	January 1966
July–December and calendar year 1965	July 1966

3. Portsmouth Area Gaseous Diffusion Plant January–June 1966 [4]

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter, and thorium–234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 4. Monthly water samples are collected at 13 stations within 5 miles of the plant.

Average airborne alpha activity showed a reduction during the first half of 1966 when compared with the final period of 1965. The alpha activity dropped from 9.7 to 7.3 percent of the concentration standard. The airborne beta-gamma activity, however, increased slightly over the previous 6-month average. The increase, from 0.01 to 0.03 percent of the beta-gamma concentration standard, is attributed to statistical counting error.

[4] Data summarized from B. Kalmon and S. H. Hulett: "Environmental Radiation Levels and Concentrations—First Half 1966," GAT 528 (September 1, 1966).

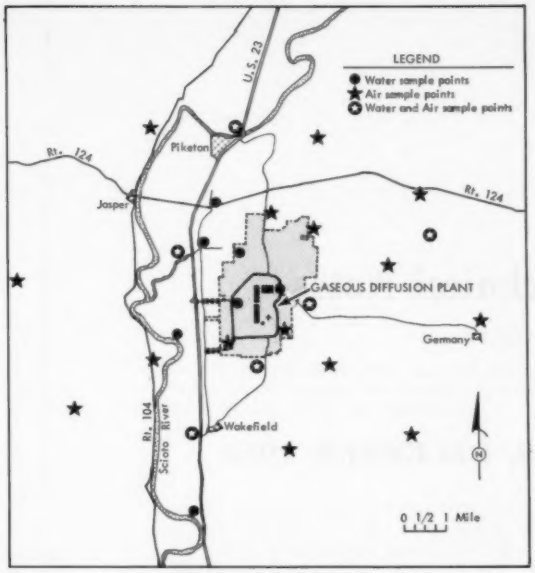

Figure 4. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

During the period January-June 1966, both the average alpha and beta-gamma radioactivities in water samples decreased to levels below those for the previous period. The average radioactivity monitored in water amounted to 0.07 percent of the AEC concentration standards for both alpha and beta-gamma emitters.

Annual background exposure rates continued to decline during the first half of 1966, decreasing from 30.0 percent to 17.7 percent of the exposure standards in the past year. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities and the continuing decline in exposure rates which followed the moratorium in nuclear testing activities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma radioactivity in air and water are summarized in table 9. The external gamma-ray levels, measured at the air sampling locations shown in figure 4, are also summarized in table 9. The overall average concentrations and background exposure rates for the first half of 1966, along with the values for the first and second half of 1965 and calendar year 1965, are presented in table 10 as percents of standards.

Table 9. Environmental radioactivity Portsmouth Plant, January–June 1966

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard [a]
Air					
Alpha radioactivity (pCi/m^3)	124	1.0	<0.1	0.1	7.3
Beta-gamma radioactivity (pCi/m^3)	124	3.3	<0.1	0.3	0.03
Water					
Alpha radioactivity, (pCi/liter)	72	171.0	<0.5	14.0	0.07
Beta-gamma radioactivity (pCi/liter)	72	238.0	<14.0	13.9	0.07
Background exposure [b] (mrad/hr)	126	0.023	<0.009	0.015	17.7

[a] The applicable AEC exposure standards are as follows:

Air (alpha)	2 pCi/m^3
Air (beta-gamma)	1,000 pCi/m^3
Water (alpha)	20,000 pCi/liter
Water (beta-gamma)	20,000 pCi/liter
External beta-gamma	500 mrad/yr (approx. 0.06 mrad/hr)

[b] Measurements were made with an open-shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration standard.

Table 10. Comparison of average concentrations Portsmouth Plant, 1965 and January-June 1966

Type of monitoring	Percent of AEC concentration or exposure standard [a]			
	1966	1965		
	First half	First half	Second half	Calendar year
Air				
Alpha radioactivity	7.3	16.1	9.7	13.8
Beta-gamma radioactivity	0.03	0.05	0.01	0.03
Water				
Alpha radioactivity	0.07	0.19	0.45	0.30
Beta-gamma radioactivity	0.07	0.49	0.18	0.32
Background exposure extrapolated to 3 feet above ground level	17.7	30.0	24.1	27.7

[a] See footnote (a), table 9.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1964	February 1965
1964	July 1965
January–June 1965	January 1966
July–December 1965	July 1966

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, DECEMBER 1966

During December 1966, three U.S. nuclear tests were reported and one Chinese mainland nuclear test was detected. Project Sterling, a 350-ton nuclear detonation experiment, was conducted on December 3, 1966. The detonation occurred some 2,700 feet underground in the Tatum Salt Dome near Hattiesburg, Mississippi. The experiment was designed to determine the extent of decoupling (a reduction of ground shock and other seismic signals) in a cavity formed by a previous nuclear detonation.

A nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground on December 13, 1966, by the U.S. Atomic Energy Commission at its Nevada Test Site. A second nuclear test of intermediate yield (200 kilotons to one megaton TNT equivalent) was conducted underground on December 20, 1966.

The U.S. Atomic Energy Commission announced detection of another nuclear test on the Chinese mainland in the atmosphere at their test site near Lop Nor on December 28, 1966. The yield was a few hundred kilotons TNT equivalent.

Preliminary analysis indicates that the fifth Chinese mainland nuclear test contained uranium–238 and enriched uranium–235 as the fissionable materials. This explosion, like the third Chinese mainland test, involved thermonuclear material. There are no indications that plutonium was used in the device.

SYNOPSIS

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A SUMMARY OF EXPOSURES TO THE OFFSITE POPULATION AS A RESULT OF NUCLEAR REACTOR TESTS CONDUCTED AT THE NUCLEAR ROCKET DEVELOPMENT STATION DURING 1965. *D. T. Oakley. Radiological Health Data and Reports, Vol. 8, January 1967, pp. 1–4.*

A summary of whole-body and thyroid exposures resulting from five nuclear reactor experiments conducted at the Nuclear Rocket Development Station during 1965 is presented. The exposures are compared with protection standards and it is shown that the exposures are small compared to the standards.

KEY WORDS: exposure-external, exposure-internal, iodine–131, iodine–133, milk, nuclear reactor tests, thyroid.

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January 1967

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g=2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie=2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs per gram

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